tech engineering news

december 1952

There's been a cold war on in Minnesota lately

. . . And our metallurgists have won it.

Up in the iron ore range, where 40 below zero can be expected frequently, shovel operators usually plan their operations to remove a year's supply of ore during warm weather months when the ore is workable. But recently, with steel requirements ever increasing, shovel operators began working around-the-calendar.

And they ran into trouble.

During one cold spell when the temperature dropped to 40° below throughout the iron ore range, the ore froze solid. The extreme cold caused steel in the equipment to lose some of its toughness, and power shovel booms and dipper sticks broke all over the range as the huge steel dippers were rammed into the frozen ore with tremendous force.

But there was one significant exception. Operators using shovels with booms and dipper sticks made of one particular steel went right on gouging up frozen ore without any equipment trouble.

Those shovels stood up because the heavily stressed parts were made from U·S·S TRI-TEN—a remarkably strong steel that has a high degree of toughness, even at low temperatures.

Moreover, the users were able to cut the weight of their TRI-TEN parts by 25%, even though some working stresses were increased 50%. "And," says one shovel manufacturer, "TRI-TEN steel has enabled our customers to operate this equipment successfully at temperatures as low as —45° F."

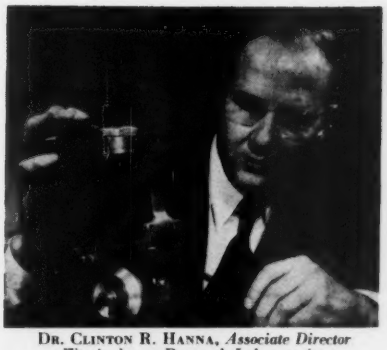
• • •

U·S·S TRI-TEN is only one of hundreds of steel compositions developed by United States Steel to meet special service conditions. Trained U. S. Steel metallurgists work with manufacturers all over the country to help solve problems involving the more efficient use of steel. United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pa.

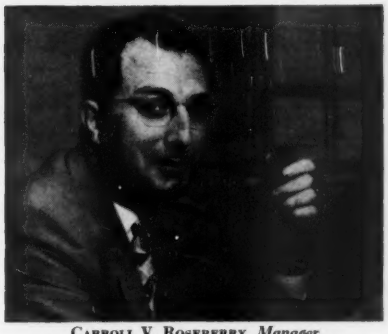
USS

2-1942

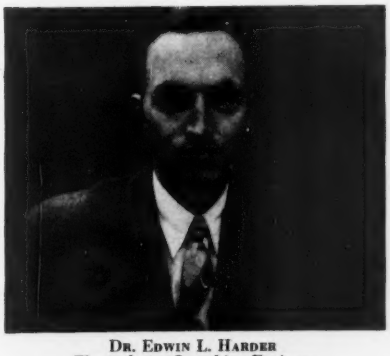
UNITED STATES STEEL



DR. CLINTON R. HANNA, *Associate Director*
Westinghouse Research Laboratories
Enrolled in Westinghouse Graduate Student Training Course after graduation from Purdue University in 1922. Dr. Hanna, with over 100 patents to his credit, is one of the nation's leading authorities on gyroscopically controlled regulating devices.



CARROLL V. ROSEBERRY, *Manager*
Westinghouse Electric Utility Department
Upon graduation from Oklahoma A & M in 1934, he enrolled in the Westinghouse Graduate Student Training Program. Assigned first as a salesman, he was advanced to district Assistant Electric Utility Manager, branch Electric Utility Supervisor, and in 1951 was appointed to his present post.



DR. EDWIN L. HARDER
Westinghouse Consulting Engineer
Enrolled in Westinghouse Graduate Student Training Course after graduation from Cornell University in 1926. Dr. Harder has become nationally known for his analytical and development work in power systems. He is co-developer of the Anacom, an electric analogue computer.

They did what you can do to achieve success

These Westinghouse executives have several things in common . . . a desire to excel, intense enjoyment of their work, and early training in their fields of specialization. All entered Westinghouse through the Graduate Student Training Program . . . the same program that today is launching young engineers on careers with Westinghouse.

You can do what these men did to achieve success. They found out early what their likings and talents were, what they wanted to do, and set their sights accordingly. With the help of the Westinghouse Training Program, you, too, can get off to a sure start on the career of your choice.

The Westinghouse Graduate Student Training Program

This program has been carefully developed through 50 years to enable top men, selected in leading colleges, to choose their careers wisely from the wide variety of opportunities available at Westinghouse. The program gives you a clear understanding of the company and its products . . . lets you try out many types of work through planned work assignments . . . and offers you the benefit of personal counsel in selecting the field for your career. The Westinghouse Graduate Student Training Program helps supply the answer to that all-important question, "Which is the *right* career for you?"

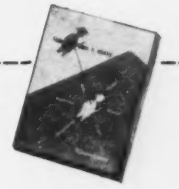
For full information on the Westinghouse Training Program, send for our 32-page book, "Finding Your Place in Industry."

G-10250

EDUCATIONAL DEPARTMENT

YOU CAN BE SURE... IF IT'S

Westinghouse



To obtain copy of "Finding Your Place in Industry", consult Placement Officer of your university, or mail this coupon to:

Mr. R. E. Davis
District Educational Co-ordinator
Westinghouse Electric Corporation
10 High Street
Boston 10, Massachusetts

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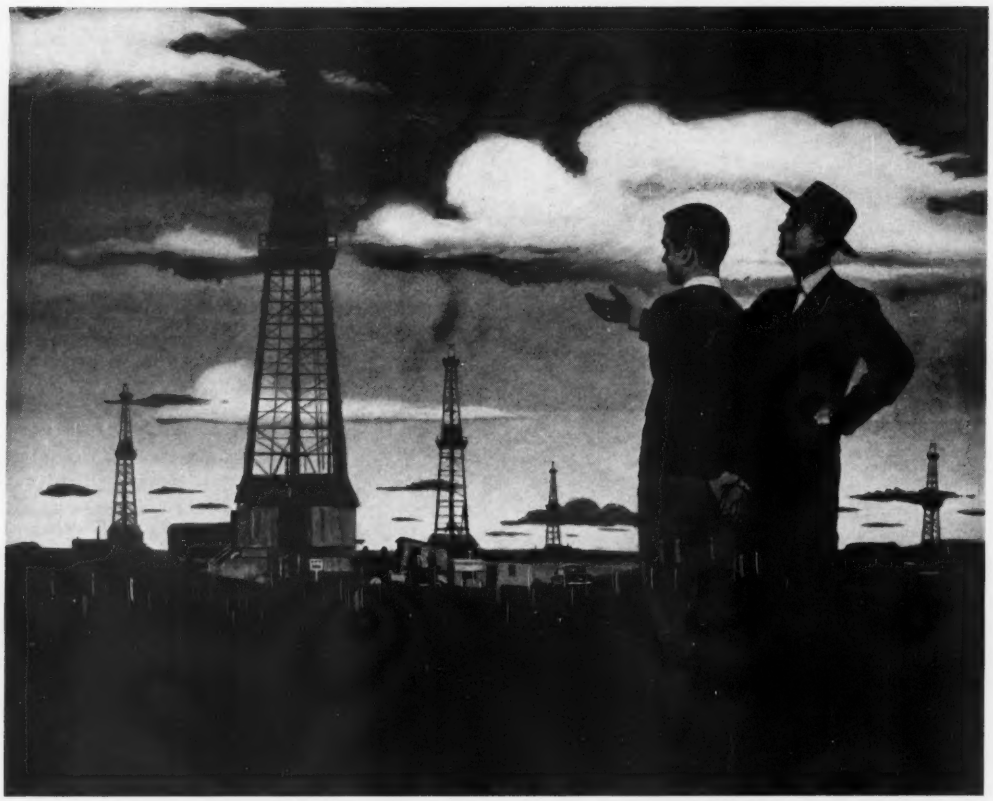


To a Young Man who wants "Room to Grow"

That's one of the attractions of the oil business as a career: big and substantial though it is today, prospects are that it has a long way yet to grow.

The discovery of new sources of petroleum and new *uses* for petroleum has gone ahead faster during the past five years than in any other comparable period. Phillips Petroleum Company gross income increased from $222 million in 1946 to $611 million in 1951. And 8,300 new job opportunities were created.

The *primary* business of Phillips Petroleum Company is producing, refining and marketing fuels and lubricants. Yet Phillips is one of the most widely diversified oil companies, and we offer opportunities for the technical graduate in many other fields: development of chemical derivatives from petroleum, ammonia and sulfur compounds, rubber synthesis, atomic research, geophysics and analytical techniques.

If you're looking for a "career with a future" we invite you to write to our Employee Relations Department for further information about opportunities with our company.

Phillips 66

PHILLIPS PETROLEUM COMPANY, Bartlesville, Oklahoma

"Look what *I'm* reading!

"No kidding, Ed . . . the EDITORIAL *page!*

"You know me, Ed...I'm strictly a sports page guy. But when I was home in bed last week with that blasted head cold, I didn't have much to do but read the paper.

"So, with time to burn, I looked at everything but the recipes . . . which is Marge's department, anyways. And, Ed, what I read in those editorials made me mad enough to forget I felt punk.

"One was about *'Creeping Socialism'*. It told what's going on right under our noses . . . a lot of undercover work to turn us into a bunch of spineless dummies, instead of free citizens.

"It warned how we *could* lose some or all of our Freedoms . . . you know, free speech, press, vote and religion. *And* the right to work or live where we please. This editorial showed how other people abroad have let socialism, then communism, take over and make slaves out of them. And all the time these people thought all they had to do was let Government *'take care of them'*. And it sure did!

"Since then, Ed, I've been reading *all* the editorials and articles . . . in newspapers *and* magazines. Been learning to think, too. And to talk things over with my neighbors and the fellows we work with down at Republic . . . things like government ownership and wasteful spending that can bankrupt a whole nation and all its citizens. Yep, I've been learning to appreciate the Freedoms that *we* have and other people *don't*. And best of all, yesterday I REGISTERED TO VOTE. . . *and my wife did, too!* That's the BIGGEST American Freedom of 'em all, and like a dope I've been too careless to protect my own and my family's interests with a ballot!

"Funny, isn't it? From a cold in the head, I got sense in the head."

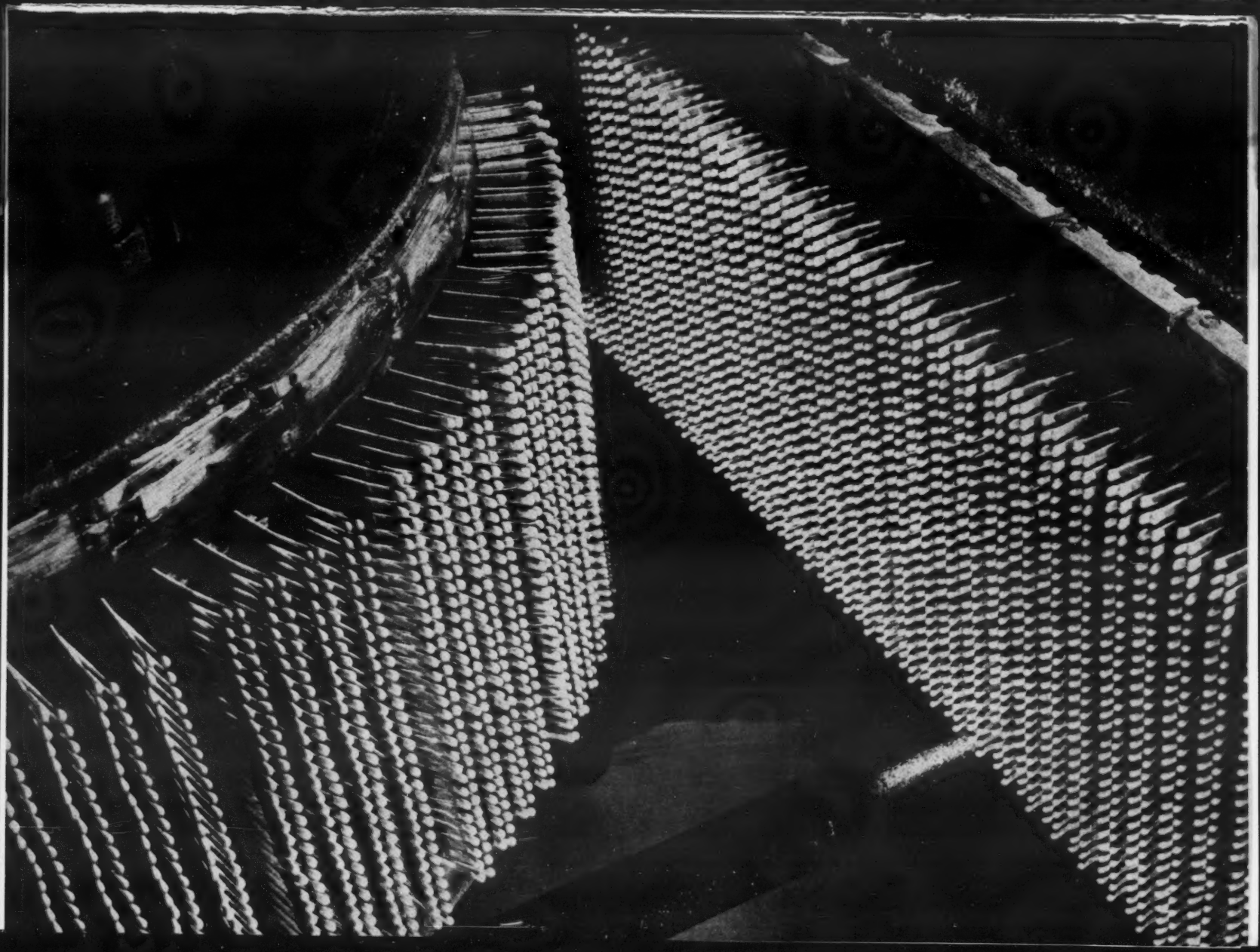
REPUBLIC STEEL

Republic Building • Cleveland 1, Ohio

Republic* BECAME *strong in a strong and free America. Republic can* REMAIN *strong only in an America that remains strong and free . . . an America whose stores are laden with the many fine products of a free Textile Industry. *And, through Textiles, Republic serves America.* Long-wearing, comfortable dress and suit materials . . . gay prints . . . smart drapery and upholstery fabrics . . . all are spun, dyed and woven on machinery made of carbon, alloy and stainless steels . . . much of them from the mills of Republic. New, almost magical synthetic fibers are today developed and produced with equipment largely made of stainless steels, notably Republic's famed ENDURO. Thus steel does its part to help keep Americans comfortably and smartly clothed the year round.

* * *

For a full color reprint of this advertisement, write Dept. H, Republic Steel, Cleveland 1, Ohio.



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FRONTISPIECE

Soldiers of Light

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Note for a faculty member's briefcase!

Recently we had the pleasure at General Motors of welcoming 19 faculty members from leading engineering schools to Detroit.

This was part of our continuing effort to discover ways in which GM can be of help in furthering the growth of engineering education in America.

And their professors informed us that they would welcome information on General Motors employment opportunities which they could pass along to their students.

In the thought, therefore, that other faculty members may share their opinion, we are publishing this message.

So we would like you to know these few simple facts about GM job opportunities.

1. They are broadly assorted—fitting a wide range of talents—from the pure scientist to the young man who sees in his engineering training a fine background for production or management work.
2. They cover a wealth of subjects—from chemistry and chemical engineering to mechanical and electrical engineering, from metallurgical engineering to industrial engineering.
3. They offer reasonable advancement for the diligent and ingenious mind. For the industrial climate at GM is conditioned by a traditional respect for the engineering point of view. Witness the number of key GM executives in both divisions and top management who began their careers as engineering graduates on GM drafting boards.

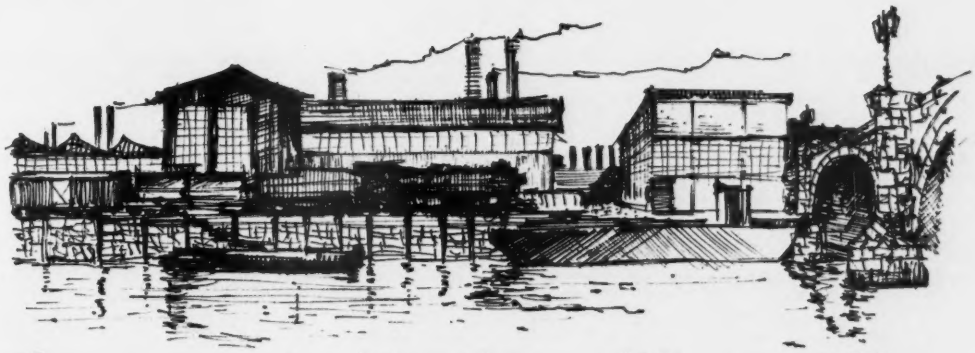
And we would like you to feel free at any time to write us, or ask our College Representative, who periodically visits your campus, any detailed questions on the subject of GM jobs for your talented students.

GM POSITIONS
NOW AVAILABLE IN
THESE FIELDS:

Mechanical Engineering
Electrical Engineering
Metallurgical Engineering
Industrial Engineering
Chemical Engineering

GENERAL MOTORS

Personnel Staff
Detroit 2, Michigan



the present situation with our allies

By Prof. George de Santillana

This is not meant to be a balanced survey, but rather, an attempt at saying the things that are usually not being said — for various reasons.

Let me begin by quoting from a fair and constructive-minded report:

"The psychological appeal is successful so long as it is based on facts . . . in the long run success will depend upon the local government's ability to deliver on their promises.

"Can the government bring about a substantial improvement in the condition of the agricultural laborers and dissatisfied farmers from whom the Communists recruit their support? . . . 'Even if we lick the Communists now, unless the land is redivided and owned by the men who farm it, we will have the problem all over again in three years — and it will be worse.'

"What are the prospects for solving the land problem? The facts are not very encouraging. . . . The Mutual Security Agency has assigned the money for the building of roads, which are necessary for gaining access to land as well as for clearing it; but no one supposes that it is possible to keep up with the increase of land-hungry peasants. . . . The contrast between rich and poor is certainly there for all to see. The poor are well aware that there has been a marked rise in the country's standard of living for the rich. For this awareness we are largely responsible — partly through the development of literacy, which exposes the countryman to advertising, and partly through the impact of the American Army during the last war. In other words, we have increased the level of expectation without increasing the means to satisfy it. Such a situation is always explosive. . . . The decisive factor is more likely to be the program of economic planning and development for which the Mutual Security Agency is the most important single instrument. The basic philosophy of the MSA is to use American aid as a strategic investment fund to increase productivity and to raise the economic level of lower income groups. . . . The planning itself requires the closest integration of political, economic, and military viewpoints, both United States and European. . . . The country is rich in resources and manpower; there is no excuse for the ever increasing unemployment and underemployment. The MSA program, as constituted today, may well achieve the objectives of increasing productivity and raising the economic level of lower income groups. But unless there is a corresponding development of industry, the economic level of the few will be raised at the expense of the many. Improvement of farming techniques means less, not more, employment. . . . There is no indication that there is any significant increase in industrial employment opportunities. For purely political reasons, if for no other, jobs must be found. The reluctance of the dominant economic interests — the commercial and landowning classes — to assist in bringing about changes which might endanger their wealth and position must be overcome. It is no secret that there is as yet hardly any prospect of serious land reform, and the minimum-wage law is honored more in the breach than in the observance. Yet it is difficult to see how there can be any great increase in agricultural productivity or large-scale industrial development unless the social patterns of the country undergo enormous changes. In the country, there is still hope of a democratic solution. For unlike China, the country has democratic institutions and have had at least one clean national election. It is possible, therefore, that the combination of American pressure from without and democratic pressure from below may break down the barriers that now stand in the way of a united and prosperous republic."

This is taken from an *Atlantic* report concerning the Philippines. It might as well apply to Europe. It expresses inimitably that curious and baffled attitude of American foreign policy which reminds one of a man trying to get a mattress past a revolving door.

A nation which has obtained leadership — or on which leadership has been thrust, it does not matter unfortunately — is expected by its followers to lead the way towards a solution. We on the other hand seem to expect that our earnest hopes plus some handouts will do the job, and we call this the cold war.

But the fact is that things are not working out, and it is beginning to stare us in the face. United States popularity has sunk to a new low throughout Europe for reasons which have nothing to do with the personal sympathy which people may still feel with American ideals, and if the countries in our zone of influence still present the "stability" that seems to be the alpha and omega of our policy, it is because people have figured out long ago that we cannot afford to have things change, and that we are even prepared to intervene in force in case something happens. As a result nothing

much happens, either good or bad. And that in itself is very bad, for the cold war is essentially a competition between the two halves of the world in successful rate of change and adjustment. The very trend that has become visible in the last year in Europe toward conservative cabinets is not so much the result of independent political decision as the fact that the "broad center" coalition governments that we had favored in the beginning have not worked out, and that since the road to the left is blocked there was no other way but to try for a more efficient government from the very vested interests who sabotaged the coalition efforts. We ourselves (I mean the State Department) seem to have come to roughly the same conclusion; i.e., we were led ourselves along the same course. In countries where really there was nothing but feudal stagnation, we had to think again. The coup which brought in Shishakli and his military government in Syria is well known to have been American sponsored, and its sequel has been the Egyptian coup of General Naguib and now the Lebanese. One might say that this is the case in which something had to happen, for the Middle East is in a helpless mess; and we had a good case when we took the responsibility of starting the process.

In Europe, where no such dire emergency exists, our Administration has carefully refrained from bringing about any violent change. This does not mean that things are coming to a solution. Far from it. Our newspapers give the bleak news that European economy is not doing so well as expected, notwithstanding its tangible increase in production, and that the dollar shortage is again becoming acute. No explanation is given, of course, news being news, and the American reader turns the page with the weary impression that the Europeans are a hopeless lot. Actually, the main cause lies right with us.

The German Democratic Republic Party joins other German parties in demanding, "Americans, Go Home!"

The sudden rise in the price of basic materials which took place after the Korean war is that cause. Our buying spree abroad, and our inflation at home, have wrecked the economic stabilization that was on the make. One of our chief economists said publicly that we have taken away from the Europeans twice as much by our inflation as we have given them with the Marshall Plan. This is something we ought to keep in mind.

The responsibilities are hard to assess. Business and labor are vying happily with each other in pushing prices up, and the Administration cannot bear the whole blame for not stopping them, since the actual pressure groups that wrecked price stabilization come from the same circles which back Taft as a candidate. Isolationism can take many forms, and this is the most active present one.

Just as a matter of background, let us remember that Europe as a continent was never self-sufficient. As long as it was able to manage its own affairs, it found enough markets for sale and investment abroad to bring in the couple of billion dollars a year that it needed for its economic balance and moderate growth. Today a good half of its foreign markets has vanished behind the Iron Curtain, another part has shrunk in South America, and as for the market that we always represented, we have given them to understand explicitly that we are going to buy nothing from them now except handbags and champagne and a few more luxury items. We have, in fact, to compete with them on practically the whole line of consumer goods abroad. Maybe nobody is at fault, but there we are. The British Empire always offered some economic solution that was acceptable to its zone of influence, and it kept thus afloat for many generations. We are offering none, and it is not strange that our allies and dependents should become restive. Yet we still control two-thirds of the productive area of the world, and a great many economic circuits could be created. But — here comes another difficulty — we are thinking of nothing but armament. It so happened that at the very time when we were disorganizing the price structure, we told the Europeans that they could count on no more Marshall aid, and that the only dollars forthcoming would be for the manufacture of weapons. This is again no way to have sound economies. Within the cramped and unstable situation of Western Europe, factors of unbalance are bound to arise, and the fact is that West Germany, owing to a combination of favorable circumstances, has suddenly started growing like a weed at the expense of everybody else. This is a situation in which we bear some responsibility, as we have been doing all sorts of favors to the Germans in exchange for their rearmament. As one of their statesmen was saying privately this summer, "Let us admit it, it is we who put this card of the German army on the table in the hope of bargaining with it. This was not honest, because no German can think of war except as the total end of Germany whoever wins. But the Americans fell so hard for it that we have been leading them along since on this one hope, without having the courage to tell them that we are never going to deliver anything worthwhile." What he said is clear to every German; for as soon as we have a West German army the

The Communists claim, "Gifts change with Time."

Russians are going to produce an East German army that they never had up to now, and Germans are not going to fight in a purely suicidal war. As one German general said, it would be good to have a few German units, but only as a bodyguard for the German government-in-exile. Thus, a German army is not going to get us much in value, and meanwhile we have created alarm and despondency throughout Europe, for the idea of a German army is bad medicine both on this and on the other side of the Iron Curtain, and Europeans are also fully aware of what the Germans are really thinking. The Germans in fact will have no difficulty in telling it. They expect their favored situation to allow them the control of Europe once more (although by purely peaceful means this time) and to be able to create in that way a European block which would affirm its neutrality in case of conflict. We have been moved to shift the center of gravity of Europe from France to Germany on the grounds that the Germans work hard, that they have excellent plumbing, and that they are good army material. These are frivolous reasons in the long run and we are paying for them by a kind of paralysis of European good will. We adjure the Europeans to think of nothing but rearmament against the common enemy, but our jittery behavior concerning the Red Menace, and our frantic looking for Communists under our beds, do not give the Europeans the feeling that we are providing realistic leadership in this incalculable crisis which might lead to the extinction of fifty per cent of their population.

The situation thus portrayed might imply that our leaders are very silly indeed and that they are out of touch with reality. I think it is unfair to accuse them. American statesmen can do no more than our public opinion allows them to do. Nor is it fair to say that our authorities on the spot are so terribly uninformed about the situation, but rather, that they are understandably timid and cagy when it comes to reporting it, because everyone fears that his report might be dug up in the files by some McCarthy or other and that he would be persecuted as other officials have been. Much less is communicated in writing than by word of mouth. Still less can be said to the public about it, for the same reasons, and there is a general frustration and helplessness about it all around. Actually there are still ways and solutions which ought not to arouse the suspicions of even the most rabid witch-hunters, but they require bold economic thinking, that had better be kept under wraps until after Election Day. This requires some explanation.

Among the many lines that the Russians are holding forth, there is one that is not often discussed, but is very present to people's minds, namely, Eurasia as an economic unit. Certain German geopoliticians had gone wild on the idea before the war. Nowadays, it is no longer a subject of imaginative speculation, for it would entail absolute Russian supremacy, and everybody knows that. Still, in a spirit of resignation, many have prepared for themselves that silver lining for the dark days of invasion. It is very true that Europe would provide a complement to the Asiatic economies. At what a price for the individual European, heaven only knows. But the fact is there. As all real economic possibilities, pleasant or unpleasant, it is working its way through all the barriers, and notwithstanding the fulminations of the American Congress, a serious volume of trade is crossing the Iron Curtain.

So the Europeans — and we — had better think up something else to take its place.

Two things had already taken shape in the European federal structure that is now in embryonic shape: the preliminary machinery for a European army, and the

steel-coal pool of the Schumann Plan. Both are beset with difficulties which make of them, as yet, only adventurous experiments. But at least they are still there, and they are bringing much new thinking to a focus. No one could have imagined in advance the tangle of complications in which they are caught at present, but at least statesmen are learning to think in terms of those complications, much as American statesmen had to figure out step by step their way to a working federal setup.

The third step has been taken in September of this year, with the announcement of the so-called Strasbourg Plan. It is quite bold; it calls for a pooling of European resources in the development of the African continent. It is almost incredibly bold on the part of men who have been experiencing the heart-rending difficulties of making even such a simple thing work as the rational distribution of Europe's own steel and coal. Yet they have had to broach it, because they know only too well that Europe must find some kind of new economic solution to its problems, or fall apart and die. The federation *in extremis* of peoples that are on the point of vanishing from the scene is a recurrent phenomenon in history; the futile antics of the Aetolian and Achaean Leagues, which brought unity too late to an already prostrated Greece, stand there as a reminder. If the nations of Europe are not to enter the colonial status, they must find a way of working and growing together. Common defense is certainly not enough. Even the most aggressive European neutralist will have to admit that the continent as it stands is in no condition to act as a third force or even as a buffer zone between the main contestants. So, if Eurasia is gone, we must have Eurafrica.

This is what men like Schumann, Monnet, Spaak, and Marjolin, who are the main planners, have fully realized. It is not difficult to follow their thinking. Europe still has capital, but its capitalism has degenerated inside closed, artificial and insecure economies. There is an abundance of skilled and semi-skilled labor, but it is either used aggressively as a bludgeon for nationalistic ends as in Germany, or pushed out of employment as in Italy, Greece or Spain. Emigration outlets are closed, and an estimated five million unemployed are a millstone that drags down national economies into stagnation, to say nothing of the growing political danger that they represent. I still remember the words of an Italian official who had to cope with the vast mass of landless farm laborers in the South: "We have always handled them as if they were lead, but they might turn out to be plutonium."

A way must be found out of stagnation, and ultimate regression. Europe's consumption of coal in 1950 was one-third of that of the United States, yet its economy is still predominantly based on coal (75%). The lagging condition of Europe can best be shown by saying that between 1913 and 1950 the total consumption of energy rose only by about twenty per cent. Coal consumption is expected to remain static, so it is oil and hydropower which will have to provide the increase. Oil has to be procured from the Middle East, an uncertain source in the years to come; hydropower on the other hand can be developed at home. American experts, in the Paley report, estimate that only twenty-five per cent of the available European water power is used at present. This is theoretical, for the last fifty per cent is going to meet steeply rising costs which may render most of it impracticable. Actually, highly electrified countries like Italy and Switzerland are beginning to

scrape the bottom of the barrel. Water is being juggled up and down between reservoirs with an ingenuity which bespeaks shrinking resources. Where, then, are Europeans going to find the raw materials (not in dollars) and the energy supply that would be needed for, let us say, a fivefold expansion of production, such as would be needed to bring the continent, in thirty years' time, up to present American standards? There isn't enough coal and oil to be bought over here, even if they had the dollars. On the other hand, it is known that Africa alone has forty per cent of the world's reserve of hydropower, almost double that of Asia together with Russia. Coupled with the mineral wealth of the continent, we have there alone the makings of new economies, and also the reservoir of electro-process material for the rest of the free world.

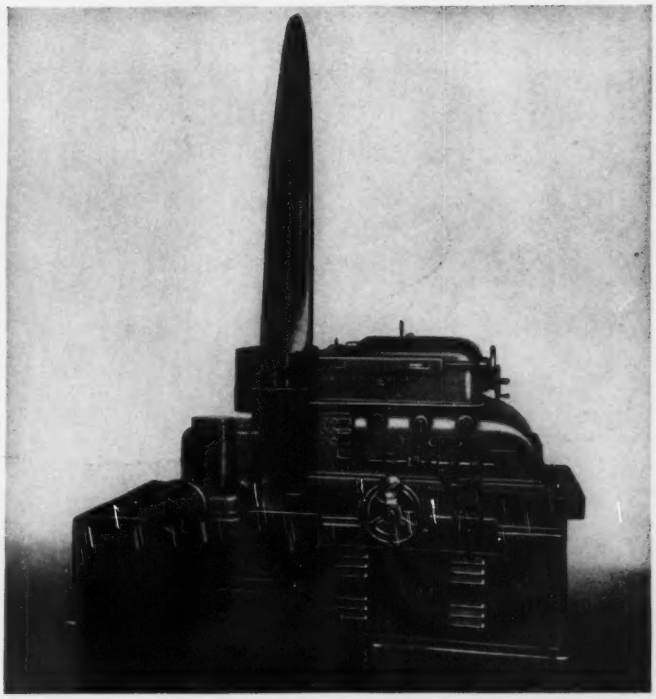
Even if a fraction of the program proved actually feasible, it would provide an expansion factor of the needed magnitude.

What we have given is only a rough indication of possibilities. The arrested situation of Europe suggests that they had better be carefully explored.

P.S. — After writing this, I have come upon a first analysis, written by Walter Lippmann, of Stalin's new book. Stalin's teaching to his people is apparently that the competition for markets within the Western world will lead to serious conflicts between blocks, and ultimately to disruption. Now Stalin is not a likeable man, but he has shown that he knows his way around, and confirmation of an economic situation by such an authority, as Lippmann himself notes, is not to be despised.

What Is this Machine?

- ☐ *a vertical miller*
- ☐ *a grinding machine*
- ☐ *a broaching machine*
- ☐ *a contour shaper*



It is a grinding machine — specifically, the new Norton Propeller Blade Hub Grinder, used to grind the external surfaces of the hubs of aircraft propeller blades

A Typical Norton Development

This specialized Norton machine brings unusual efficiency to propeller grinding operations. As shown, the propeller blade is held *vertically* — by a workholding fixture on a work spindle with an anti-friction bearing — a new departure that avoids the errors normally caused by deflection when the blade is held *horizontally*, as in conventional methods.

The new Norton grinder has many other improved features adding up to greater speed, accuracy and simplicity of operation. And it requires considerably less floor space than do horizontal machines adapted for the same purpose.

The Broadest Line

The Norton line of grinders and lappers is the most complete offered by any single manufacturer. It runs from small machines for the tool room to high precision, high volume units for heaviest production line duty. Equipped with Norton abrasive wheels these machines form unbeatable combinations for efficient, economical grinding.

To Future Technicians

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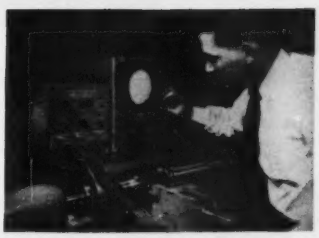

Guy D. Metcalf, B. S., E. E., Worcester Polytechnic Institute '49, checks smoothness of master cam spindle with specially designed electronic equipment — in connection with his work on Norton cam and contour grinders.

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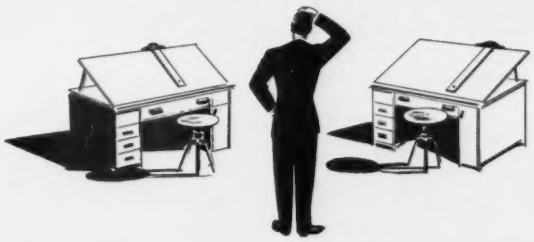

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helium at low temperatures

The Story of Nature's Wonderful Problem Child

By Garry L. Quinn, '56

Although man has recently begun to manufacture chemical elements, he has not ceased to be amazed by those made by Nature. Of the ninety or so naturally occurring elements, the most surprising is helium.

While helium occurs in significant quantities on earth, it was first discovered in the sun. During the total eclipse of the sun of August 18, 1868, several observers in different places noticed in the spectrum of solar prominences a vivid yellow line which did not belong to any element then known. When the existence of this line had been confirmed by subsequent observations, Lockyer postulated a new element to account for it and gave that element the name Helium from the Greek *helios*, sun. In 1895 helium was found on earth in various uranium ores and in natural gas. The element was later found in minute quantities associated with atmospheric argon.

Investigation showed that helium is a gas having an atomic weight less than that of any other element except hydrogen and that it belongs to the select group of inert or "noble" gases, i.e., elements which do not form stable compound with any other element. Because it is light and will not burn, helium is commonly used for filling balloons and airships. A more interesting quality of helium is that it is more nearly a perfect gas than any other element. For this reason it is favored for use in gas thermometers. Even at −270 degrees Centigrade the reading of a helium thermometer varies from the thermodynamic scale by less than .045 degrees.

Important work is being done amid the seeming clutter of the M. I. T. low temperature lab. In spite of the seemingly hopeless confusion, each person is assigned a definite working space and keeps his region in order.

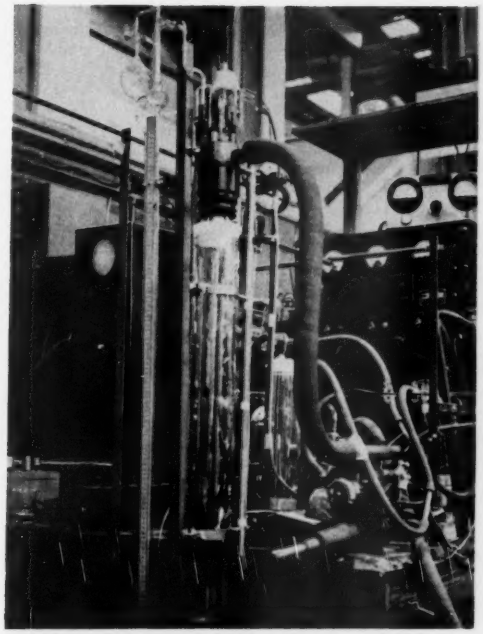
Shortly after the discovery of helium on earth, attempts were made to liquefy it. The process which had been successful in liquefying hydrogen — compressing it to one hundred forty atmospheres, cooling to the temperature of liquid air, then letting it expand suddenly — was tried with no results. For several years helium withstood high pressures and low temperatures and defied science to liquefy it. On July 10, 1908, the Dutch physicist Kamerlingh Onnes succeeded in producing liquid helium by cooling the gas with liquid hydrogen and then expanding it rapidly. The boiling point of helium has been determined at 4.22 degrees Absolute at a pressure of one atmosphere. Thus the first surprising aspect of liquid helium is its low condensation temperature.

Attempts to solidify helium met with even less success than early tries at liquefying it. In 1926 Keesom first produced the solid state, using a pressure of 122 atmospheres. Later considerations showed that solid helium cannot exist even at absolute zero without a minimum pressure of at least 21.2 atmospheres.

Measurements on liquid helium show that as the temperature falls to 2.2 degrees Absolute a rise occurs in the specific heat. Then at 2.19 degrees, within an interval of a few thousandths of a degree, the specific heat falls from a value of 3.0 to a value of about 1.1 cal./g. degree. Measurements of several other properties reveal anomalies at the temperature of 2.19 degrees. The properties of the liquid above and below this point are so different that the higher temperature state has been given the distinguishing name Helium I and the lower temperature state, Helium II. The point of transition from one form to the other is called the λ(lambda)-point. As it was found that there is no latent heat of transformation at the λ-point, the change is said to be a second-order transition. Just how important that transition is we shall now see.

Measurements of the viscosity of liquid helium show that above the λ-point it is abnormal in temperature dependence. Unlike any other liquid, the viscosity of liquid helium does not increase with a decrease in temperature. Determinations of the viscosity of liquid helium below the λ-point revealed an even greater abnormality.

It is found that the value of the viscosity of liquid helium II depends on the manner in which it is measured. If it is measured by the damping of the motion of a disc oscillating in a bath of the substance, a curve is found beginning at the λ-point at a value somewhat higher than the last value for helium I above the λ-point and rapidly falling away towards zero. If, on the other hand, the viscosity is measured for flow through a capillary, the value found



Typical apparatus used in the low temperature lab. The large glass cylinder is a dewar flask containing liquid nitrogen. Within it is a smaller dewar containing the liquid helium.

is very nearly zero. In addition to the zero viscosity, quite abnormal phenomena are observed. The velocity of the flow is almost independent of the pressure head and the cross section of the capillary, and can take place under almost no pressure gradient.

A disturbing property of liquid helium II is its refusal to be bounded by a container. If a test tube full of helium II is lowered into a bath of the same substance, so that the level of the helium in the test tube is different from that outside, the two levels will gradually become equal. It has been shown that a film of liquid helium about 3.5×10^{-6} cm. in thickness creeps over the walls of the test tube at a rate of up to fifteen cm./sec. If the test tube is lifted out of the helium bath, the film creeps up out of the tube, down the outside, and drips off the bottom. If the tube is placed in the bath and the level of the helium allowed to equalize, and then a small heater is placed in the tube, the helium will creep into the tube until it stands several millimeters higher than in the bath.

Obviously a theory is necessary to account for the unique properties of liquid helium II. Although it is not scientifically exact, it is conventional to speak of helium II in terms of the "two-fluid" theory. This postulates that helium II is composed of two components, each with its own density and pressure independent of the other. One of the components is an ordinary liquid like helium I. The other is composed of helium atoms in their lowest energy state, i.e., it is stable at absolute zero. The state of these atoms, however, is not one of rest. The atoms have a certain residual energy of translation and possess appreciable momentum. In helium, a light element with small interatomic forces, the residual energy is particularly great. In order to account for observed phenomena, there must be a gap between the lowest energy level and the next higher, so that an atom in the lowest state cannot absorb an arbitrarily small amount of momentum. As the atoms in this state cannot dissipate momentum, their flow is free from viscosity, and they make up a "superfluid."

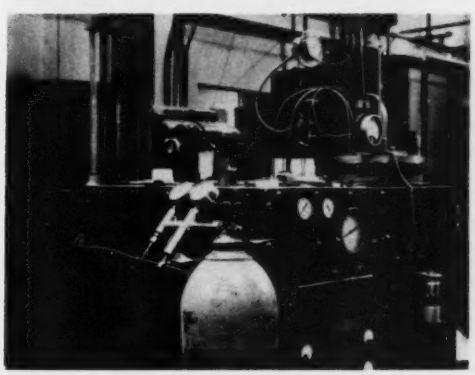
At absolute zero, all helium atoms are in the lowest-energy or superfluid state. At the λ-point, all the atoms have absorbed energy and have ceased to be superfluid. Between absolute zero and the λ-point, the ratio of normal and "superfluid" atoms is a function of the temperature only.

Now the discrepancy in the viscosity experiments may be explained. When an oscillating disk is put in liquid helium II, it encounters viscosity from the "normal" liquid, and its motion is damped. At lower temperatures, there is less "normal" liquid and so less viscosity. When helium II passes through a capillary, however, it is only the "superfluid" which flows. The rate of transfer of normal liquid through the capillary, if any, is negligible. The viscosity observed is that of the "superfluid," or zero. Inasmuch as the atoms are being transferred by their residual momentum, there is no need for a pressure head. No momentum can be dissipated, so there is no pressure gradient across the capillary. The ease with which helium II creeps along a wall with which it is in contact is likewise explained by the large residual momentum, zero viscosity, and small interatomic forces of "superfluid."

Let us see what happens when a temperature gradient is established in helium II. As the helium in the vicinity of the heat source absorbs the heat, a portion of it is transformed from "superfluid" to normal liquid. Inasmuch as each of the two components of helium II has its own pressure, a pressure gradient will occur in the normal liquid in a direction away from the heat source and in the "superfluid" toward the heat source. Simultaneous and equal currents of the two components occur, but in opposite directions. By this process of mass transfer, helium II can "conduct" a great deal of heat. In fact, helium II is the best heat conductor known. The conductivity at its maximum value is two thousand times that of copper at room temperature.

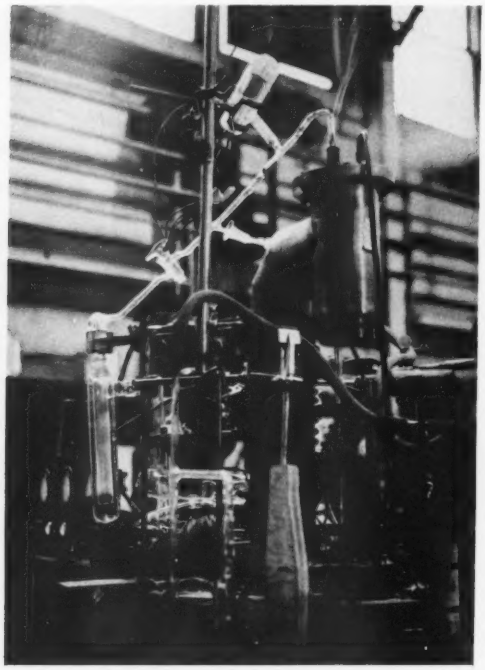
The fact that a temperature gradient in helium II

The cryostat, heart of any low temperature lab. It will produce from three to six liters of liquid helium per hour. It was developed by Professor Collins of M. I. T.



always produces a pressure gradient may be made more vivid by another experiment. A U-tube, the bottom of which is packed with emery powder, is immersed in a bath of helium II. The emery is then heated by illumination by a small lamp. A pressure gradient results in the two components of the helium. The "superfluid" can pass through the capillary openings in the emery to equalize the pressure, but the normal liquid is trapped. As a result a stream of liquid helium spurts out of the end of the tube to a height of several centimeters above the level of the bath.

The opposite of this "fountain effect" also occurs. If liquid helium II is forced through a capillary, the temperature of the helium leaving the capillary is lower than that of the helium entering. Here again it is only the "superfluid" which passes through the capillary. Being in its ground state, the "superfluid" conveys no kinetic energy. The heat energy, belonging only to the normal component, is left behind to be distributed throughout a smaller volume of liquid helium. Thus the temperature (but not the heat content) rises.



Part of the complicated apparatus used for measuring magnetic susceptibility at low temperatures.

As has been stated before, the "two-fluid" theory of helium should not be taken too seriously. It should serve, and has served, rather, as a working model from which to deduce the real nature of liquid helium. A strict theory has not yet been settled upon. The most important theories of liquid helium are those developments of the "two-fluid" concept put forth by Laszio Tisza of M. I. T. and L. Landau of the U.S.S.R. The two theories are parallel in many respects, but the interpretation given to certain phenomena differ, mainly in approach. At this stage it is obvious that the final theory of liquid helium will be neither Tisza's nor Landau's, nor a synthesis of the two, but a combination of elements of both with new ideas not yet advanced.

Work, both theoretical and experimental, is being conducted on the liquid helium problem. Before World War II there were only about half a dozen laboratories — led by that at Leiden — capable of conducting extensive research at the temperature of liquid helium. Today there are more than five times that number. The rapid progress in low temperature research may be credited in very great measure to the perfection of the helium cryostat by Dr. S. C. Collins of the M. I. T. Mechanical Engineering Department. Working at the Institute under an Army Air Force contract, Dr. Collins produced a machine with an experimental chamber that can be cooled to the temperature of liquid helium and below. The refrigeration is produced by the adiabatic expansion of helium. A counterflow heat exchanger makes possible the compression of gaseous helium at room temperature and its subsequent expansion at very low temperatures. With a few improvements the machine has been built in numbers by A. D. Little Co. during the last six years. Forty-three are now in service, two of them at the M. I. T. Low Temperature Laboratory. Since their installation they have produced thousands of liters of liquid helium without a major breakdown.

The M. I. T. Low Temperature Laboratory was set up shortly after World War II as a part of the Research Laboratory of Electronics in order to investigate microwave phenomena at low temperatures. It has since added many other lines of low temperature research. Important work has been done on pressure and temperature dependence of liquid helium phenomena. Outside of the helium problem, the Low Temperature Lab has made valuable investigations of electrical resistance minima in metals. Current research is directed towards continuation of previous investigations below one degree Absolute. These experiments are particularly important because it is at these lowest temperatures that "superfluid" becomes the dominating component of Helium II. It may soon become possible to separate its properties from those of the "normal" component. Physics will then be one step closer to a complete theory of liquid helium.

The Low Temperature Laboratory is secluded in the little-known Wing D of Building 20. Its floor space of sixty feet by half as much appears to contain an acre of equipment. Pumps, pipes, hoses, Dewar flasks, and electrical equipment form a seemingly impenetrable jungle. Yet, miraculously, everyone has room to do his work. Each researcher has a corner in which he can put his equipment, his elbows, and little else. The greater part of the research is done by candidates for Bachelors', Masters', and Doctors' degrees in support of their thesis requirement.

At the Low Temperature Laboratory one of the frontiers of theoretical physics is being explored. The theory of helium II — which is often called a "quantum liquid" — is as of great interest as the theory of atomic energy. The work being done at the Low Temperature Laboratory is as important to the development of modern physics as that being carried out at Brookhaven or Los Alamos. Helium is a problem. M. I. T. is helping to solve it.

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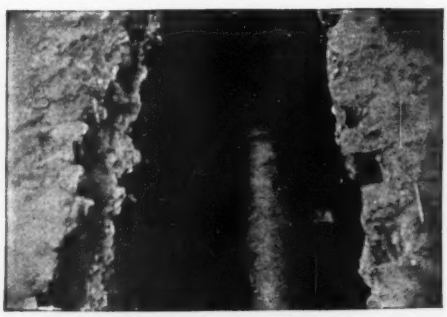

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switching circuit techniques

By H. J. Simmons, '54

Switching circuit techniques, until recent years, were of use mainly in the fields of telephone communication and computer mechanisms. However, there has been developing among businessmen a greater interest in more efficient systems of keeping records. It is in this area that switching circuits are once again useful. These active storage machines collect, store, and revise data on such things as factory inventories. The advantage of such a machine is that the information obtained from it is correct up until the very minute you receive it. The inventory machine could be designed to record shipments to and from the plant even within the past hour. The Union Switch and Signal Division of Westinghouse Air Brake Company has developed such a device known as *Infomat*. The *Infomat* has a central storage unit which is connected to various small units located in ticket agencies throughout the city. When a sale is made of some train space, the notice of such a sale is transmitted to the central unit, which records it. In this way the information obtained from the *Infomat* on the availability of reservations on various trains is complete up to the very moment that the inquiry is made. It is in connection with the understanding of how such a machine might work that the truly elementary principles of switching circuits are of value.

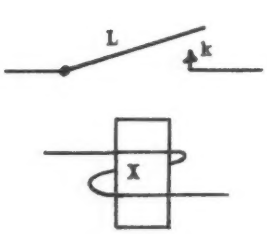
In the construction of these active storage mechanisms, use has been made of electromagnetic switches rather than electronic switching equipment. Although the sensitivity and quick action of the electronic tubes and semi-conductors suit the requirements of high-speed computors, the reliability, longer life, lower power consumption, and flexibility as circuit elements make relays the more desirable equipment for use in storage devices.

There are a great many different types of electromagnetic switches, often called relays, but the most basic and the most widely used relays are the two valued ones. These have but two positions, open and closed. In figure 1-a and 1-b representations of the two valued relay are shown. Energizing the electromagnet (X) in figure 1-a will cause the metallic arm (L) to be forced against the contact (k), thus closing the switch. In 1-b the electromagnet forces the arm away from the contact (k') causing the switch to open. Both of these arrangements are combined in one switch as shown in figure 1-c. The arm is returned to its normal position when the electromagnet is de-energized by spring action. A single relay may contain any number of one or all of these switches, so that the energizing of a single relay will open some switches and close others. Since other relays may be considered as combinations and variations of the two valued type and are of limited use, there is no need to consider them at this time.

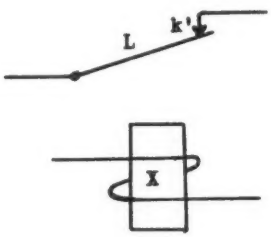
There are two basic relay control paths. The first involves immediate action, such as the simple closing of a circuit when a switch is closed and the breaking of the same circuit when the switch is opened again. The two types of immediate action control paths are shown in figure 2-a and 2-b. Closing switch (A) energizes the electromagnet (X) which forces the arm (L) away from contact (k') and against the contact (k). In 2-b the electromagnet is energized by opening switch (A). In both cases the arm returns to its normal position when the electromagnet is de-energized. (R) in figure 2-b is a current limiting resistor.

The second control path imparts the quality of memory to the machine. There are two memory paths. The lock-up circuit is shown in figure 3-a. Switch (B) is initially closed. Closing switch (A) energizes the magnet, forcing the arm against the contact. Switch (A) may now be opened and closed without effect. Switch (B) serves as an eraser, since momentarily opening (B) will permit the arm to return to its normal position where (A) once again exerts control over it.

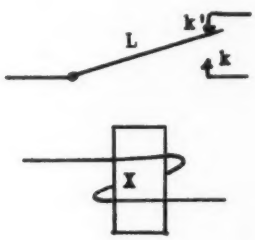
The lock-down memory path is shown in figure 3-b. (A) and (B) are initially closed switches. The current is shunted away from the electromagnet through switch (B). Opening (B) energizes the magnet, forcing the arm away from the contact. Opening and closing



(1-a) Make Contact



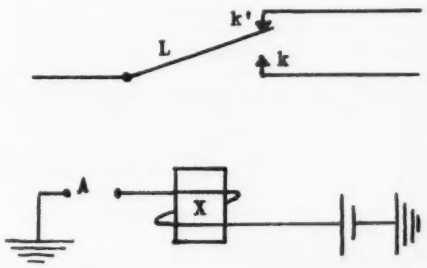
(1-b) Break Contact



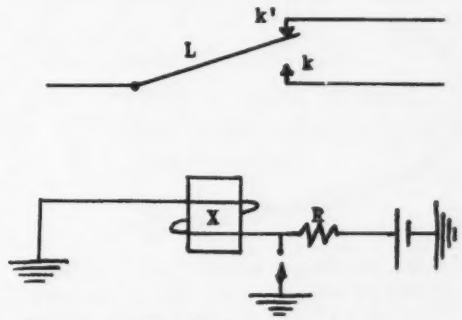
(1-c) Break-Make Contact

(B) will now have no effect. Opening the eraser switch, (A), momentarily, permits the arm to return to its normal position where B now exerts control.

In attempting to arrange the relays in some order, we are motivated by certain conditions to which our machine must respond. If a circuit is to be completed or broken when two contacts are operated together, the contacts should be connected in series. For example, if a given circuit is to close when both relays (A) and (B) are energized, we would connect a make contact of (A) in series with a make contact of (B). On the other hand, if the circuit were to be completed when either (A) or (B) were energized, it would be necessary to connect a make contact of (A) in multiple with a make contact of (B). The above considerations lead us to term a series connection an "and" connection and the multiple connection an "or" connection.



(2-a) Immediate Action by Direct Control



(2-b) Immediate Action by Shunt Control

After laying down certain conditions, we proceed to design the circuits and discover that interpretation of the drawings is more work than the original designing. Some simplification of the drawings is made by omitting the diagram of the electromagnet.

Even this omission does not truly remedy the confusion. As a further aid to simple circuit representation, a system of literal notation has been developed. Each relay is designated by a capital letter, A or B or C or . . . , and each contact of the relay by the small form of the relay's letter. Make contacts are denoted by the plain small letter and break contacts by the small letter primed. The "and" connections are identified with a plus sign. Make contact a in series with break contact b' would be written

$$a + b'$$

An "or" connection is identified with the multiplication dot. Make contact a connected in multiple with make contact b would be written

$$ab$$

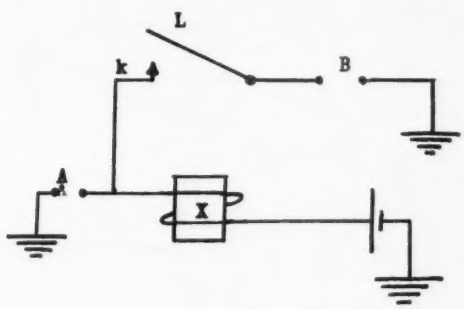
The circuit shown in figure 5 would be written

$$a + (b + a')\,(c)$$

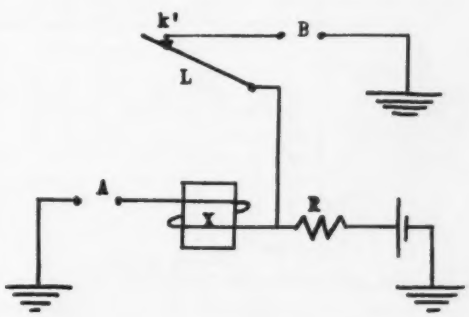
This notation completely describes the relay circuit, and might suggest to some that algebraic operations might be performed on the circuit expressions. This is actually the case. We now assign a character 1 to the open contact and a character 0 to the closed contact. It is often a help to think of these characters as real numbers that represent the impedances of the contacts, a closed contact having no impedance and an open contact having an impedance of 1. The characters obey the following postulates.

(a) $x \pm x'$
(b) $x = 0$ or $x = 1$
(c) $0\ 0 = 0$
(d) $1 + 1 = 1$
(e) $1\ 1 = 1$
(f) $0 + 0 = 0$
(g) $0\ 1 = 1\ 0 = 0$
(h) $0 + 1 = 1 + 0 = 1$

From these postulates several theorems can be proved



(3-a) Memory by Lock Up

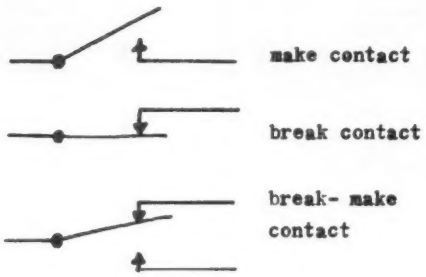


(3-b) Memory by Lock Down

switching circuits

by perfect induction; that is, they can be shown to be true for all (both) values of the variables. The most important of these theorems are as follows:

(1) $x + y = y + x$
(2) $x\,y = yx$
(3) $x + y + z = x + (y + z) = (x + y) + z$
(4) $xyz = (xy)z = x(yz)$
(5) $(x + y)(x + z) = x + yz$
(6) $x + x = x$



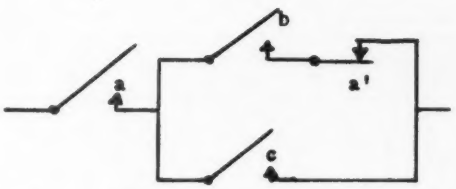
(4)

(7) $xx = x$
(8) $x + xy = x$
(9) $x' + x = 1$
(10) $x'x = 0$
(11) $0 + x = x$
(12) $1x = x$
(13) $1 + x = 1$
(14) $0x = 0$

With these postulates and theorems it is possible to operate on our expressions algebraically. If we wanted to know under what conditions the circuit shown in figure 5 would be open (would not conduct current), we would have to set the circuit expression equal to 1 and solve for the variables.

$$a + (a' + b)\,c = 1$$

Our solution is $a = 0$ (closed) implying $a' = 1$ (open)
$c = 1$ (open) b is arbitrary



(5) System of Relays

The algebra may also be used to simplify the more complex circuits. Suppose we want a circuit to close when relay A is energized but B, C, D are not, or when C and B are energized and A is not, or when D and C are energized and A is not, or when A is energized and either B and C or B and D are not. The circuit shown in figure 6 satisfies these conditions. In literal notation the circuit becomes

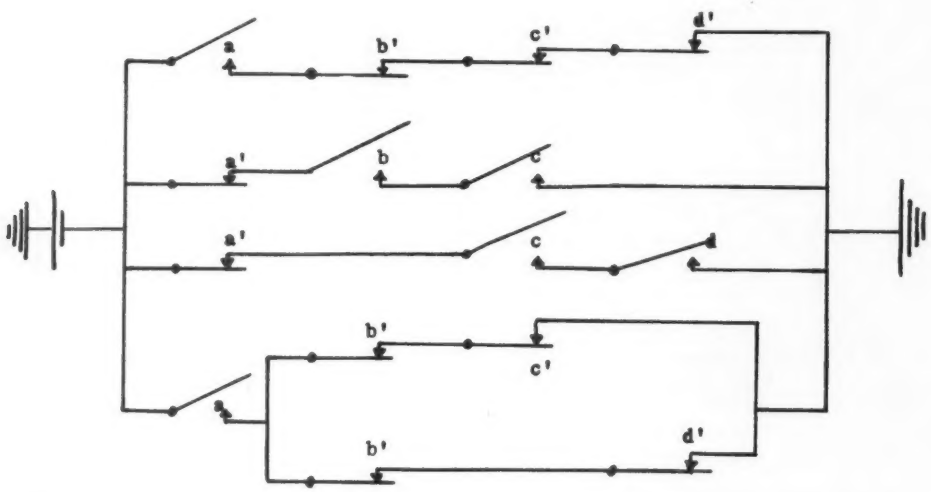
$$[a + (b' + c')(b' + d')](a + b' + c' + d')(a' + b + c)(a' + c + d)$$

We now algebraically simplify the equation.

$$a + (b' + c')(b' + d') = a + b' + c'b'$$
$$(a + b' + c'd')(a + b' + c' + d')$$
$$= a(1 + b' + c' + d' + b') + b'(1 + c' + d') + c'd'(a + b + 1)$$
$$= a + b' + c'd'$$

and

$$(a' + b + c)(a' + c + d) = a'(1 + c + d + b + c) + bd + c(1 + d + b) = a' + bd + c$$



(6) Original Circuit

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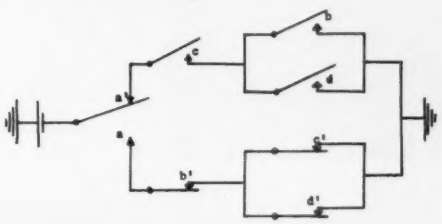
Therefore,

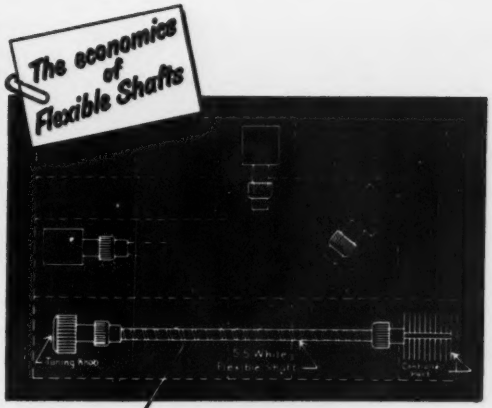
$$[a+(b'+c')(b'+d')]\,(a+b'+c'+d')(a'+b+c)$$
$$(a'+c+d)=(a+b'+c'd')(a'+bd+c)$$

The drawing of this simplified version of our original circuit appears in figure 7. Note that the total number of contacts used has been cut from fifteen to seven. Depending on the order and type of operations performed on the circuit expression, many versions of our original circuit may be derived algebraically, but all of these are, from the standpoint of the conditions that they satisfy and mathematically, equivalent.

While it is true that the circuit in figure 6 might have been simplified by inspection of the circuit and the conditions, as the number of relays, contacts, and conditions to be satisfied increase, solution by inspection is difficult and may lead to errors of omission. The algebraic simplification always leads to results that are entirely equivalent to the original system and works for any number of relays and contacts. The algebra may also be applied to two valued electronic switching equipment.

(7) Simplified Circuit





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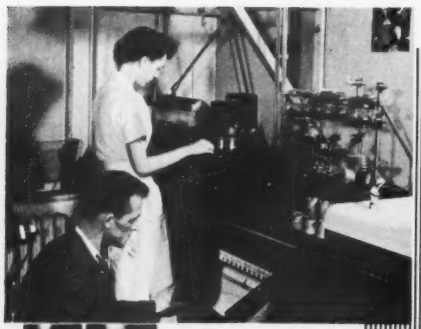
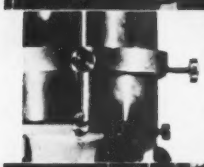


Making an analysis with the infra-red Spectrophotometer.



Testing action of Perchlorethylene on various metals.

Focusing the Electron Microscope on a chemical sample to be photographed.

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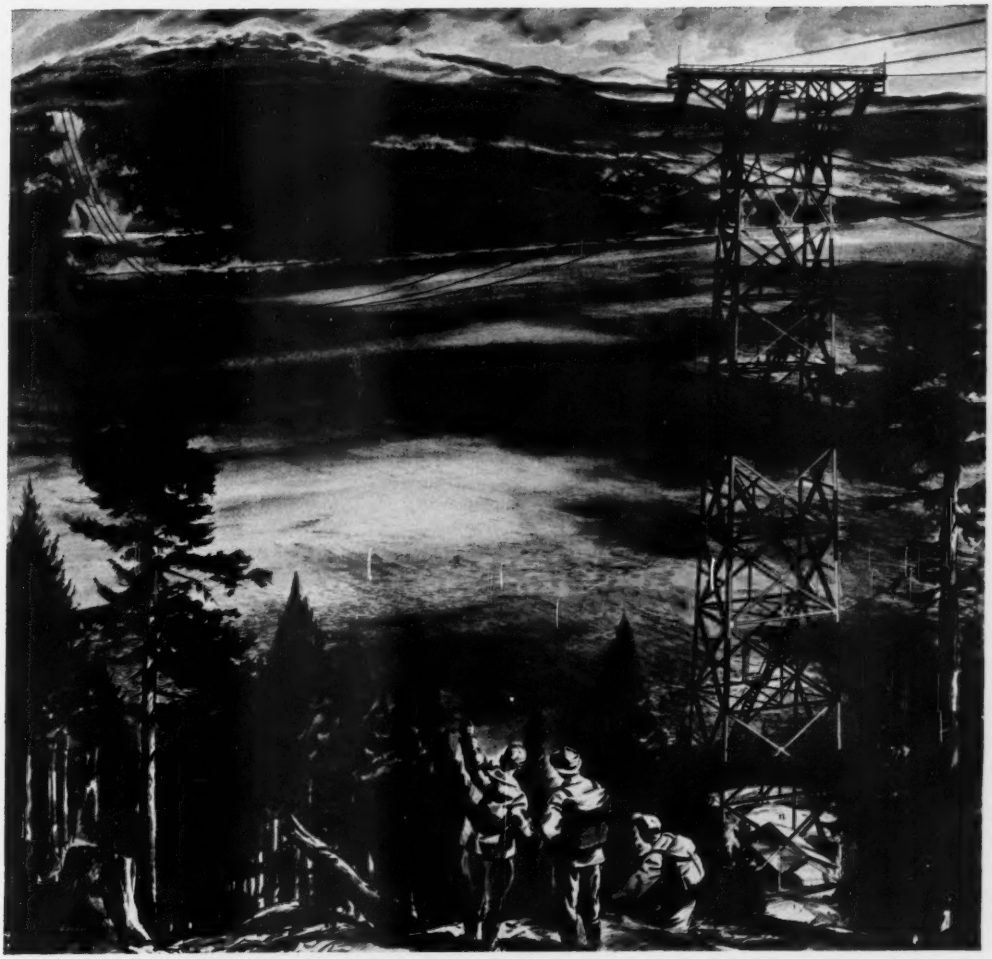

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from the editor's notebook

A Great Pastime

We Techmen are a pretty busy lot. Some of us do homework regularly; we all goof off frequently. Most of us spend many hours engaged in a great pastime that is here to stay: shooting the bull. My contention is that an hour spent on bull sessions is as beneficial as an hour spent on homework.

Of course the prime appeal of a bull session is simply the pleasure it affords to all involved. Probably everyone's favorite sound is that of his own voice. We all enjoy having our opinions listened to and weighed. For at least a short time each person has the attention of the whole group. But bull sessions provide many other less obvious, yet really greater, benefits.

For one thing, we are forced to review our own thoughts. We often form opinions, and sometimes very strong ones, merely on the basis of vague impressions gleaned from various random sources. We seldom review these opinions unless there is a reason for doing so. Often our unconsidered thoughts turn out to be completely inconsistent. Exposing these half-jelled impressions to critical analysis is a sure means of eliminating some of their vagueness and self-contradictions. In other words, a good serious discussion forces us to think about the things which we have been too lazy to consider before.

Another prime benefit from a discussion is more social in nature; the ability to listen while other people speak is an extremely valuable asset that is completely lacking in some individuals. The nature of a bull session makes an exchange of opinions necessary; a sermon by one person is seldom interesting to anyone but the speaker. The differing opinions expressed by the members of the group will doubtlessly have at least some common basis upon which everyone can agree. An understanding of the differing opinions is almost sure to lead to greater tolerance of opposing views of all subjects. Even though there may be violent disagreement about the final conclusions, if each member of the group tries to see all sides of a question a great step forward has been achieved.

Most important of all, I think, is the insight a good bull session gives on the true characters of the participants. Thorough knowledge of a person requires familiarity with his opinions and ideals as well as with his personality and habits. It is more difficult to learn his actual feelings in many months' daily contact than by one good discussion. This understanding of the feelings of others almost always leads to deeper friendships.

Frequent bull sessions can benefit an individual immensely. They broadened the views of one of my friends immensely. He was one of the nicest guys I knew when he flunked out of Tech.

New Format of the Magazine

As we hope you have noticed by now, this issue of *T. E. N.* is laid out on an entirely different plan from any previous issue. Each article is printed on consecutive pages until it is complete, rather than being continued in the back. This form is still experimental; we would like to hear what our readers think. Let us know how we could improve the magazine in any way. Would you like to see our articles more technical? More science fiction? There will always be someone in our office in the basement of Walker from five to six. Drop down and give us your opinion. If we do not hear your suggestions, we can only assume that we are giving you roughly what you want. Are we?

— J. S. M.

those foreign handguns

Small Weapons from Abroad

By Jon Jansen, '56

Since the First World War, foreign handguns have been coming into the United States in increasing numbers. Most of these have been brought back by returning soldiers as war souvenirs; some have been imported by large mail-order houses; a few have been brought back by tourists or individual collectors. These foreign handguns come in all makes and calibers and range from excellent to very poor in quality.

Some owners of foreign handguns keep them merely as collector's items, but a majority of them are interested in firing the guns as well. Immediately the following questions arise: What is the make and caliber of the gun? What type of ammunition does it use? Can the proper ammunition be obtained in this country? Is the gun safe to use with American ammunition?

In this article I shall describe the principal types of foreign handguns and try to answer some of the above questions about them.

The first general group of foreign handguns is that of military weapons of various countries. These pistols became very plentiful after the last war and present more of a problem than do the other groups. They are medium and large caliber automatic pistols.

Perhaps the most famous of all foreign pistols is the German Luger. The Luger has been the official sidearm of the German Army since 1908 and has been well known in this country for years. It employs an unusual breech mechanism and is fairly complex, with close tolerances throughout. The Luger will sometimes jam if it is not well oiled, and generally it requires a great deal of care. It must be cleaned frequently. The gun comes in two calibers; 7.65 mm. (.30 caliber) and 9 mm. (.38 caliber), and ammunition for both sizes is easily obtained in this country. A Luger in good condition is perfectly safe to use with American ammunition and is a very desirable handgun. One should be wary of Lugers made in the 1916–1918 and 1943–1945 periods, for those made under wartime conditions did not receive high quality material or workmanship.

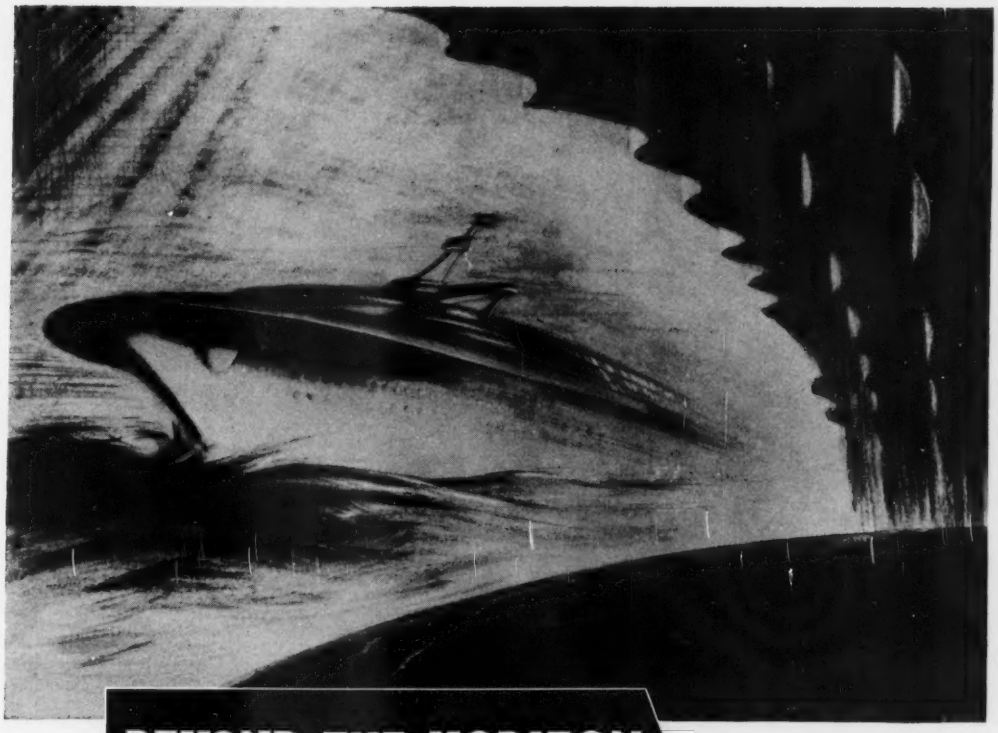
The famous German Luger, a precision made gun.

The first successful automatic pistol used by the German army was this Mauser.

One of the first successful automatic pistols to be adopted by any military establishment is the Mauser 1898. It has been a German sidearm for over fifty years. It is different from most automatics in that its magazine is in front of the trigger guard and is not detachable; the Mauser loads through the top with a strip charger instead. It is strong, simple, and well made. It comes in three calibers; 7.63 mm. (.30), 9mm., Luger, and 9 mm. Mauser, which is very rare. Mausers chambered for 9 mm. Luger have a large figure "9" carved into the grips and painted red. Both 7.63 and 9 mm. Luger shells are easily obtained in this country, and the Mauser is perfectly safe with American ammunition. The Mauser, though somewhat clumsy and unbalanced, is nevertheless very accurate and is an excellent gun in every way.

Since 1920 copies of the Mauser have appeared on the market under the names of Azul, Astra, and Royal. These were produced by Spanish concerns for the South American and Chinese markets. Their parts are not interchangeable with those of the Mauser, and they have minor differences in construction and mechanism. Generally speaking, they are not as good as the Mauser and are not always safe to fire. One should consult a gunsmith before firing one.

Another common German side-



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arm which was used during the last war was the Walther P-38. Of the same caliber as the Luger, it differed in that it was a double action automatic of simpler design. The gun was good but had several faults. The shape of the handle gave the gun a tendency to recoil downward, making it rather inaccurate. Also, the trigger connecting bar or the breech lock, both small but important parts, were occasionally left out when the gun was assembled. This had disastrous effects. Otherwise the P-38 is well made and safe to use with American ammunition. One should have it checked over by a gunsmith before firing.

A famous Belgian handgun is the Browning 1935, by Fabrique Nationale. It is the last of the Browning designs. It differs only slightly from the Colt .45 automatic in general design and is very well made. It is of 9 mm. Luger caliber and can be used with any 9 mm. Luger ammunition. The Browning 1935 is very accurate and has a large magazine capacity, fifteen shots, making it a very desirable shooting gun.

The official sidearm of the Polish Army before the war was the Radom 1935, whose manufacture was continued under the German occupation. The Radom is of 9 mm. Luger caliber and follows the general Browning pattern of handgun design. It is a heavy, sturdily built automatic which works well with American ammunition. Although some Radoms are roughly finished and have loose tolerances, many models are well made. Those made under the Germans were of increasingly poor quality as the war progressed. A prewar Radom, however, is an excellent shooting gun.

The Glisenti has been the official Italian sidearm through both wars. Resembling the Luger in general outward appearance, it has the "prop-up" locking system of the military Mauser. It is at best only mediocre in design, material, workmanship, and performance. It is 9 mm. Luger caliber but uses an Italian load of reduced power. One should not try to use American or German ammunition in a Glisenti, for its action is rather weak and its steel comparatively soft.

A poor copy of the Luger is this Italian Glisenti.

The Mauser pocket pistol is one of the larger and better guns made for concealment.

The Beretta 1934 was another Italian military sidearm, although it should belong to the pocket pistol class because of its small size and low power cartridge. It has no breech locking mechanism but depends on the recoil spring instead. A distinguishing feature is the front of the magazine, which protrudes beyond the butt to form an extended grip. It uses the 9 mm. Corto (short), which is the same as the American .380 pistol cartridge. Prewar Berettas were well made, and one in good condition makes an excellent pocket pistol.

The Russians developed a simplified copy of the Browning called the Tokarev. It is still one of their official sidearms. It is chambered for the 7.62 mm. Russian pistol cartridge, which is interchangeable with the 7.63 mm. Mauser cartridge. The pistol is too light for the cartridge it takes, but is well built and will work well with American and German ammunition. It has no safety devices except the half-cock in the hammer. Another distinguishing feature is the grips, which are grooved up and down instead of being checkered and have a star carved into them. It is generally roughly finished with loose tolerances, but is strong and simple and will stand up well. The Tokarev is not very accurate because of its poor sights and excessive recoil.

The Japanese automatic, the Nambu 1914, was adapted from the Luger and Glisenti design and has been the official sidearm of the Japanese Army through both World Wars. It greatly resembles the Glisenti in appearance and general structure, but is of superior design. It is chambered for the 8 mm. pistol cartridge, which is manufactured only in Japan. It will not func-

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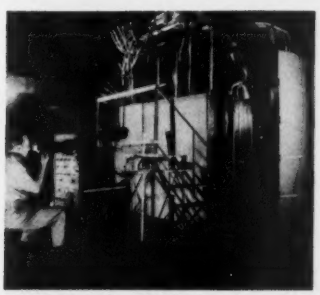

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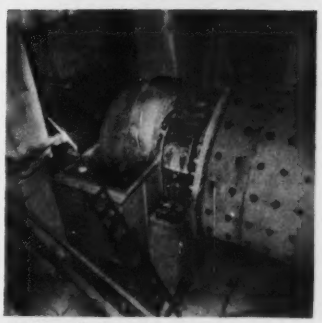

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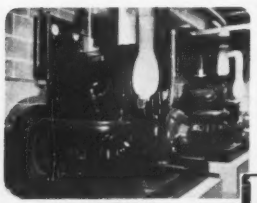
Installation by L. V. Fleiter Co., St. Louis Distributors who have put Frick cooling equipment in five other super-markets recently.



Frick NEW "ECLIPSE" Compressors at Bettendorf's Super-Market, St. Louis

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those foreign handguns

tion with any other cartridge. A few prewar Nambus were well made, but after the war began the quality declined rapidly.

The other important group of foreign handguns is that of the small pocket pistols. These are generally automatics of small caliber intended for concealment. Practically all of them use the 6.35 mm., 7.65 mm., or 9 mm. short pistol cartridges, which are the same as the .25-, .32-, and .380-caliber pistol cartridges used in this country. Although there are many makes of pocket pistols, there is not nearly the diversity of design to be found among pocket weapons as there is in military sidearms. Moreover, their design is generally simple.

Among the best pocket pistols are the Walther Models PP and PPK. The Walther PP is a double action hammer automatic originally developed as a small police and military sidearm. It comes in two calibers, .32 and .380. Prewar Walthers were among the world's best made handguns. The PPK is a smaller, more compact version of the PP. Both are excellent handguns.

The Mauser Model 1910 is one of the largest pocket pistols, and its longer barrel makes it more accurate than most pistols in its class. It is very well made and has several unusual features. When the gun is cocked, the striker protrudes through the back of the frame. When the magazine is empty, the gun will lock. It is necessary to insert a magazine to unlock it. The Mauser 1910 comes in .25 and .32 calibers.

The Ortgies is another excellent German pocket pistol. It is of very compact design and has an unusual safety mechanism that can be released by squeezing the handle. The Ortgies is very difficult to take apart. It is a very attractive and desirable weapon.

One of the most advanced pocket pistols is the Mauser H Sc, a streamlined double action pistol. The tapering shape of the trigger guard makes it a rather unusual looking weapon. Its caliber is .32. The H Sc is very well made and finished.

Belgium's Fabrique Nationale plant turns out the Browning 1910, a compact, well-made weapon of .32 and .380 caliber. The Browning has the same general design features of the Colt line except that the mainspring is around instead of underneath the barrel; thus the gun does not have the square appearance of the Colt. The Model 1922 is identical with the Model 1910 except for the increased barrel length and magazine capacity. It is a very well made gun.

In addition to the pocket pistols already described, there is a large group of small automatics which are direct or near copies of the Colt .25. These are too numerous and too nearly alike to discuss in this article. It is sufficient to say that they closely resemble the Colt .25 in both appearance and operation. Even most of the poorly made ones are safe to use with low-powered cartridges. When in doubt about such a weapon, consult a gunsmith.

Target pistols form a much smaller group than do military or pocket pistols. They use .22 long or long rifle cartridges and resemble their American counterparts in appearance and operation. They are generally well made and finished. Many foreign target automatics are very desirable guns in every way.

Another type of target pistol is the free pistol, which is single shot, custom made, and .22 caliber. They are well made and are often very elaborate.

A streamlined double action pistol of high quality, the Mauser H Sc.

.32 ACP

MAUSER
H Sc

This is the Boeing team's jet heavyweight

Here is a flight shot of the giant Boeing B-52 Stratofortress. An eight-jet heavy bomber, the Stratofort is a fast, husky teammate to the B-47 Stratojet medium bomber. It's 153 feet long, measures 185 feet from wing-tip to wing-tip, and is powered by eight Pratt & Whitney J-57 engines. Speed and other performance details are carefully guarded secrets.

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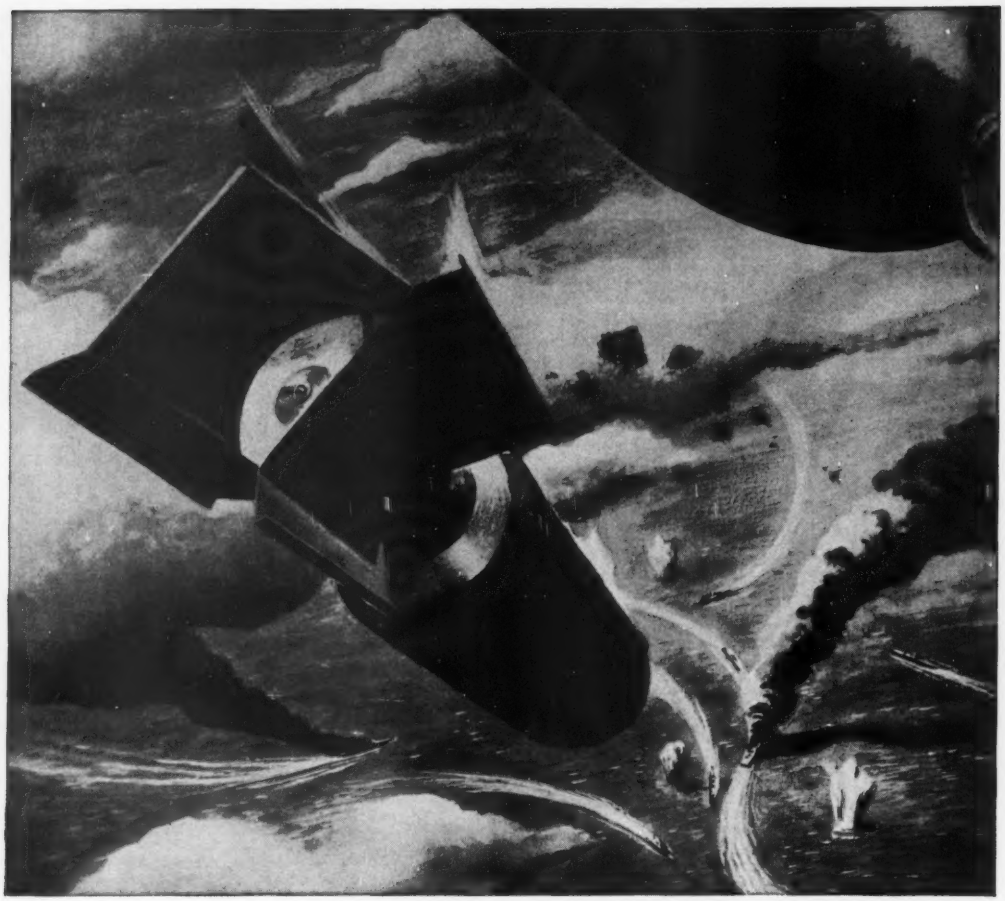

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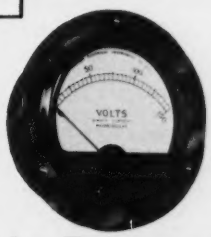
about permanent alnico magnets

automatic control—permanent magnets are partners in industrial progress

One important part of the "automatic" factory is the requirement that measuring devices be accurate, rugged . . . and because of their use in such great volume they have to be low cost. It is a credit to instrument manufacturers that these meter miracles are being accomplished. Not only are the meters more sensitive, lower cost . . . but specialized problems in measurement are solved everyday with new and different instruments.



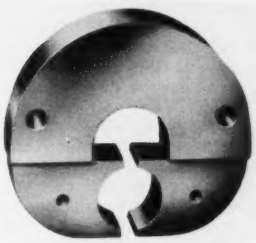
Marion Meter, Model 53RN.

here's how Marion cut magnet costs 1/3 ...and built a better meter!

Marion Electrical Instrument Company, prominent meter manufacturer, embarked on a plan of redesigning their meters to give improved service. The Marion Meter, Model 53RN shown here, is a good example of what is being accomplished.

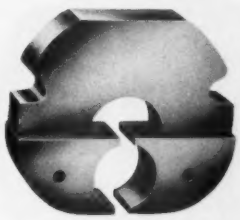
In redesigning their instruments, Marion worked closely with Crucible magnet specialists. The recommendation was made to change from Alnico II to Alnico V for the magnetic alloy used in the meter's D'Arsonval movement. Then the magnet itself was redesigned. The overall effect was to reduce the weight of the magnet by 35%, cut the cost ⅓ . . . and increase the gap flux density which resulted in a 15% increase in the torque of the movement. The illustration shows the old and new design.

This development is typical of how Crucible is working to increase measuring efficiency with permanent alnico magnets. Have you a magnet application we can cut costs on by ⅓?



Former design of magnet assembly using Alnico II.

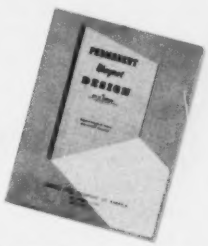
before



Note how redesigned magnet is made lighter because of reductions in area. The change from Alnico II to Alnico V with this design improved flux density.

after

magnet data book available



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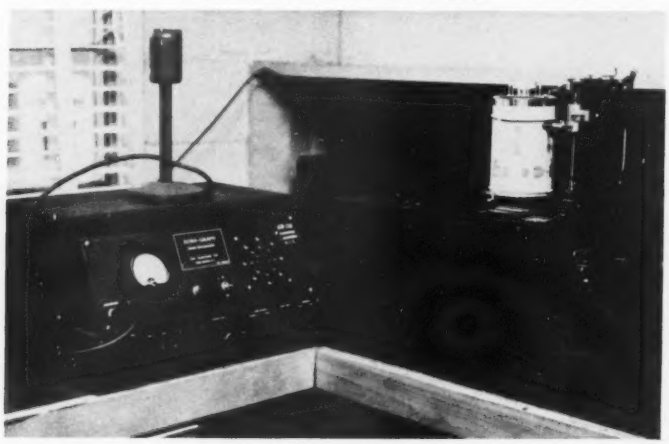
speech analysis and the spectrograph

By Ken Klopf, '56

Humans have been talking for a long time, but what is really understood about speech? In answer to this question it must be admitted that until recently only the fundamentals of the production of vocal sounds were known. There were many theories proposed concerning the production of speech, but even the generally accepted ones were speculative concerning the details on the operation of the voice apparatus. After the discovery of the penetrating properties of x-rays, the human vocal tract could be observed during the generation of sounds and qualitative data could be obtained on the movements and dimensions of the vocal apparatus. In 1888 a great stride was taken in speech analysis by several European philologists when they developed the Improved Roman Alphabet, or, as it is more commonly known, the International Phonetic Alphabet. Since each letter of this new alphabet represented a basic vocal sound, the alphabet represented a new tool for the studying of speech throughout the world. Phoneticians developed great skill in the reproduction of the basic sounds and developed many concepts concerning the production of human speech. In July, 1946, in the *Journal of the Acoustical Society of America*, the Bell Telephone Laboratories announced the use of the sound spectrograph in the study of sounds. This instrument analyzed sounds and produced a graph containing frequency-intensity versus time information and through its use the various phonetic sounds were analyzed. In November, 1950 the Acoustical Society of America printed the proceedings of the Speech Communication Conference which was held at M. I. T. the previous June. At this conference the calculation of vowel resonances and also the operation of an electrical vocal tract were described. The electrical vocal tract is an analogue of the human vocal cavities and is used together with x-ray pictures of the human vocal apparatus to develop a better understanding of the production of speech.

Why would the production of speech be advantageous? The answer can best be given by a few examples. One illustration is the study of foreign languages and dialects. The French vowels and the letter "r," the German "r" and fricatives, the English "th," and the various stresses of non-native languages are particularly difficult to pronounce. Through the knowledge of how the vocal apparatus is positioned these sounds can more easily be achieved. This knowledge can also aid in correcting speech defects and in teaching the deaf to speak naturally. Another more spectacular use of this knowledge may result in the development of a voice-typewriter which would record spoken information on paper.



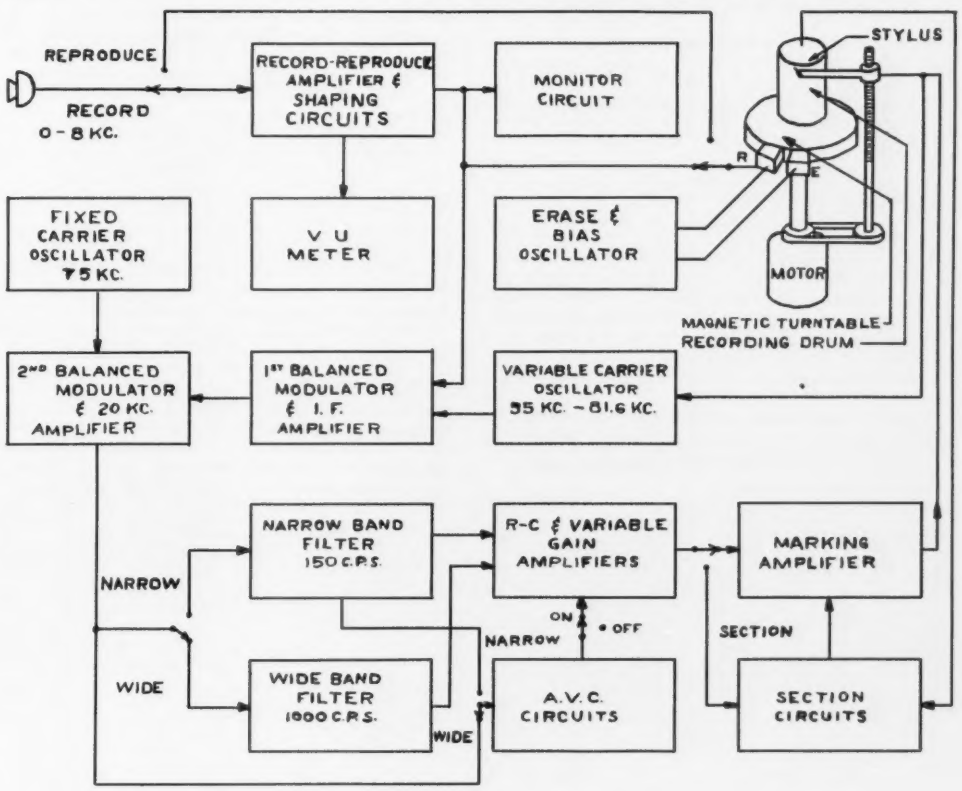
The M. I. T. sound spectrograph, consisting of a power supply (background) analyzer (left) and recorder (right). The drumlike object is the magnetic turntable used to record the sound.

Before the sound analysis equipment can be profitably discussed a basic knowledge of the speech processes and characteristics must be obtained. The vocal process starts at the brain which sends messages to the various muscles used. One of these muscles, the diaphragm, compresses the lungs to send a stream of air up through the larynx, which contains the vocal cords. The vocal cords consist of two horizontal bands of elastic tissue which can be spread or brought together by the muscular network in the larynx. The muscular network also controls the tension of the vocal cords. When the stream of air passes through the opening between the vocal cords the cords vibrate. The vibrations of the vocal cords therefore produce pulsations in the air stream above the larynx. The vibrating air stream flows through the throat cavity over the hump of the tongue through the mouth cavity and through the constriction formed by the teeth and lips to the outside air where the sound is propagated. The output of air above the vocal cords has a high harmonic content and the transmission of each harmonic is primarily dependent upon the dimensions of the cavities and constrictions through which the air flows. Therefore the output sound from the lips can be varied by changing the dimensions of the vocal tract. The primary articulators are the tongue and

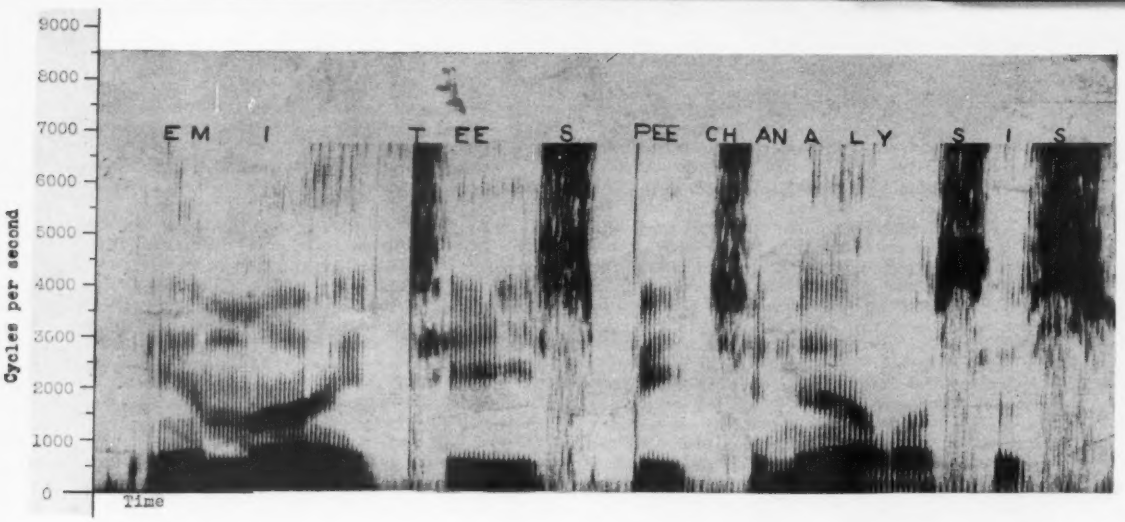
lips, which move almost continually throughout active speech. This continual movement results in a constantly changing output with respect to frequency, amplitude, and time. The four basic methods of modulating the flow of air through the vocal tract are named start-stop, vocal cord, frictional, and cavity modulation. The first three types of modulation affect the flow of air from the lungs through the vocal tract, whereas the cavity modulation varies the quality of the sound output. Start-stop modulation occurs less than ten times a second and it is characterized by pauses in speech, as in the spaces between words. Vocal cord modulation is the vibration of the vocal cords which periodically interrupt the flow of air in the vocal tract. The fundamental frequencies of the vocal cords vary between seventy-five and five hundred cycles per second. The output air through the vocal cords is rich in overtones. Frictional modulation is caused by the friction of the air flow through the vocal tract and is characterized by the fricative sounds such as "s," "f," "sh," "h," etc. The spectrum of frictional modulation is continuous, and contains a wide range of frequencies. Cavity modulation acts on the overtones produced by vocal cord and frictional modulation. By changing the dimensions of the throat and mouth cavities certain frequencies are suppressed while others are accentuated. Each sound emitted from the vocal tract is produced by one or a combination of several of the various methods of modulation. The sounds "p," "t," and "k" are called stop or plosive sounds (sometimes stop frictional sounds) and are created by a combination of stop, frictional, and cavity modulation. The sounds "b," "d," and "g" are called voiced stop sounds and are created by stop, frictional, and vocal cord modulation. The sounds "z" and "v" are called voice fricatives and are produced by vocal cord, friction and cavity modulation. In all vowels and similar sounds only vocal cord and cavity modulation are employed. The principles discussed are the chief identification factors used in the speech analysis and synthesis equipment which will be described in this article. For other methods of speech work one observes stress, inflection, vibrato, vocal quality, and other characteristics.

Speech is composed of a mixture of pure tones having varying intensity and frequency. This makes it inevitable that successful instruments used to analyze speech would plot frequency-intensity on a time base. The oscilloscope would seem to fulfill this requirement perfectly, and it has been used extensively in speech analysis. However, the evaluation of the complex oscilloscope pattern requires time. The sound spectrograph records frequency on a vertical scale. The sound

Figure 1. A block diagram of the sound spectrograph showing the essential features of the instrument.



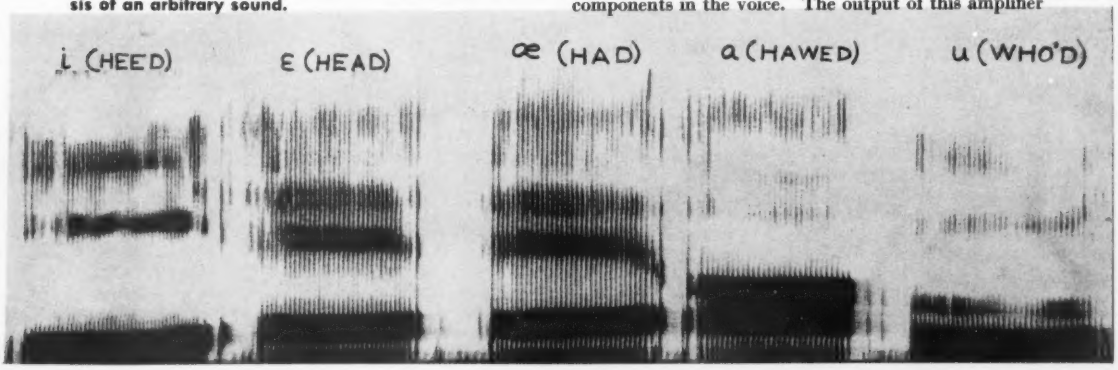
SOUND SPECTROGRAPH (TYPICAL)



speech analysis

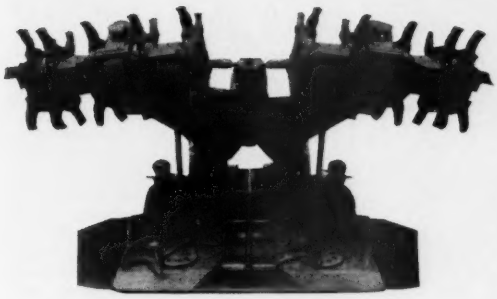
spectrograph breaks down the complex speech wave by means of filters into its component frequencies with their corresponding amplitudes. It then plots the output on a linear time base. The spectrograph described in this article has an upper frequency limit of approximately eight kilocycles and a recording time of 2.4 seconds. The equipment requires about five minutes to complete an analysis of the 2.4 second recording on dry facsimile paper (approximately 4 inches by 12 inches). Fundamentally the sound spectrograph discussed is typical of all models now being used. Essentially the equipment consists of a magnetic recorder that is used to record the speech sample to be analyzed and also to repeatedly reproduce the sample so that complete analysis may be effected. The repeating sample of speech is analyzed for the various frequency components by a variable filter. The variable filter starts at the lower end of the voice spectrum and completes an analyses using a bandwidth of either forty-five or three hundred cycles per second. The output is then recorded by an electrical stylus on the bottom of the facsimile paper. The intensity of the low frequencies scanned is indicated by the gradient from white to black so that dark regions on the spectrograph indicate frequencies whose amplitudes are high. On the next repetition of the recorded sample the variable filter scans a higher frequency range with either the narrow or wide bandwidth circuits. The recording stylus then records the frequency components scanned above the information previously scanned. The magnetic recorder continually reproduces the voice sample until the voice frequencies are completely recorded on the facsimile paper. The speech analysis is then used to check the characteristics of speech. A study of the block diagram (Figure 1) will indicate more completely the operation of the sound spectrograph. When recording a speech sample the synchronous motor drives the magnetic turntable twenty-four r.p.m. and the recording stylus is lifted from the recording drum. The speech to be analyzed is then spoken into the microphone and applied to the record-reproduce amplifier and shaping circuits. This block is used to amplify the signal applied to it and also to allow the insertion of spectrum shaping circuits. One of these circuits has a flat frequency response up to eight thousand cycles and another increases the high frequencies fifteen db. The accentuation of highs is used when recording speech because of the rapid drop off of intensity of the high frequency components in the voice. The output of this amplifier

The sound spectrogram of the words "M. I. T. speech analysis." The total time represented by the spectrogram is about two seconds. The vertical displacement is proportional to the frequency of the component of sound.



The sound spectrogram of five common vowel sounds. Note the characteristic dark bands of each sound. These bars are very valuable in the analysis of an arbitrary sound.

Another page for **YOUR BEARING NOTEBOOK**



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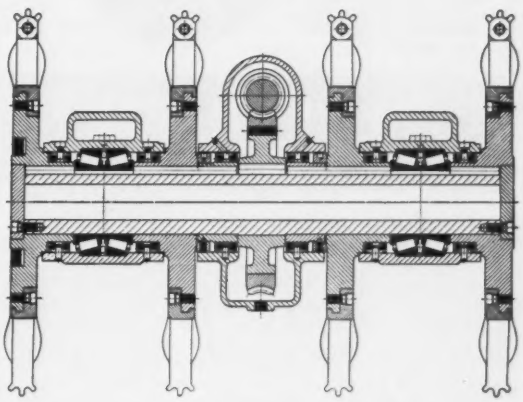

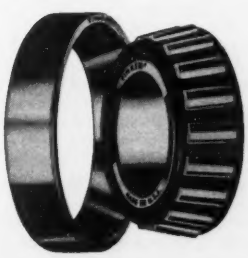

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speech analysis

circuit is applied to a VU meter to obtain an indication of volume level and it is also applied to the monitor circuit which contains a power amplifier and a loud-speaker for monitoring purposes. The output of the record-reproduce amplifier is applied to the record-reproduce magnetic head on the rim of the rotating magnetic turntable. An erase head is placed before the recording head to remove any previous recordings and transient noises. The maximum speech sample to be recorded cannot have a length of over 2.4 seconds because of the rotating speed of the magnetic turntable. When the recording is ceased the last 2.4 seconds of speech will be on the magnetic drum. When the switches are turned to "reproduce," the magnetic turntable and recording drum rotate at eighty r.p.m. thus effectively increasing the frequency recorded on the magnetic drum by a factor of 3.33. This indicates that if the input frequency from the microphone were eight thousand cycles per second then on reproduce the frequency would be 26.6 kc. Thus the frequency range being picked up by the record-reproduce will vary from 0 to 26.6 kc. The sample speech from the record-reproduce head is applied to essentially a variable filter operating over the frequency range up to 26.6 kc. This operation is accomplished by the variable carrier oscillator which changes its output frequency as the stylus moves up on the recording drum.

Through the utilization of the sound spectrograph, speech sounds can be conveniently analyzed into their frequency-intensity components. By the use of this equipment it is shown that the vowel sounds consist of certain resonances combining on the pattern to show horizontal bars representing the bands of resonant frequencies. The sound spectrograph also shows that the spectrum of fricative sounds is continuous and similar in nature to that of random noise. Because of the prominence of a second resonance bar from the base line the spectrograms, after practice, may be read with as much facility as one versed in the symbols of the phonetic alphabet reads speeches or exercises written with phonetic symbols. Many characteristics of speech have been observed by the use of the sound spectrograph. It has been seen that each vowel and vowel-like sound has a different relative position for resonance bar, enabling easy recognition of these sounds. This fact has been checked for male, female, and foreign speech and leads to the assumption that different speakers have approximately the same resonance bars for the same sounds. This characteristic is due to both physiological and psycho-sociological reasons. Because the human vocal apparatus is anatomically the same for all speakers and human speech is largely imitative starting from childhood, where children learn to speak by imitating their elders. After reaching maturity, people imitate the sounds surrounding them in the various social groups. Other sounds (consonants and combinations) have been observed to have relatively fixed patterns. All of these characteristics together make the reading of visible speech within the grasp of anyone interested in the science of speech analysis. Stressed speech is indicated on the sound plots by dark patterns and the tendency of individual sounds to appear like pure sounds. For more information on the interpretation of visible sound patterns the book *Visible Speech* by R. K. Potter, G. A. Kopp, and H. C. Green will be of invaluable aid.

At the present time research is being done throughout the world on speech analysis. Here at M. I. T. the Acoustics Laboratory, the Research Laboratory of Electronics and the Modern Languages Department are actively working on the problems of human speech and the equipment necessary to analyze it. Work is now being done analyzing the similarities and differences of human speech, using patterns obtained from the sound spectrograph.

It is interesting to note the various uses of sound analysis. In the analysis of vocal and instrumental music, various effects can be examined and defined by the use of a sound spectrogram. The use and interpretation of the sound spectrogram would allow a singer to scrutinize and improve the vocal qualities of presentation. Naturalists would be able to analyze the sounds of various insects, animals, and birds, and to formulate the method by which these sounds are created. Also in the future a voice typewriter may be developed which will be able to transpose vocal sounds into printed characters. The typewriter will have to analyze each group of sounds and then operate a circuit so that the proper printed character will be applied to the paper. The alphabet used in the voice-typewriter will probably be either the present International Phonetic Alphabet or an extension.

THE DU PONT DIGEST

Plant and Equipment Design and the Engineer

At Du Pont, men with many types of training translate laboratory developments into full-scale production

Roger Jones, *B.S. in Chem., Haverford College '52 (right), and operator check temperature control in the conversion of furfural to furan.*

Among the most interesting fields for engineers at Du Pont is the design of plants and equipment.

It takes ingenuity of a high order to translate a small-scale laboratory operation into all-out commerical production. Design engineers cannot always use purchasable equipment to scale up research findings, even with considerable adaption. About half of the time at Du Pont, entirely new equipment must be designed because of the novelty of the process developed by research.

For example, a number of unusual problems were involved in designing the equipment and plant for a process in which hexamethylenediamine, one of the intermediates for nylon, is made from furfural, derived from such agricultural by-products as corncobs and hulls of cottonseed, oats and rice.

In this conversion, these steps are involved:

$$C_4H_3OCHO \xrightarrow[\text{catalyst}]{\text{Heat}} C_4H_4O$$
furfural → furan

$$2H_2 \longrightarrow C_4H_8O$$
tetrahydrofuran

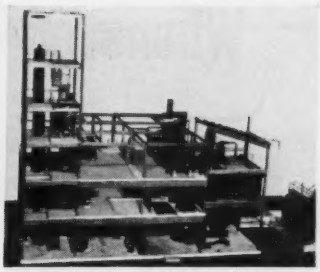
$$2HCl \longrightarrow Cl(CH_2)_4\,Cl$$
dichlorobutane

$$2NaCN \longrightarrow NC(CH_2)_4\,CN$$
adiponitrile

$$4H_2 \longrightarrow H_2N(CH_2)_6\,NH_2$$
hexamethylenediamine

Here are some of the special problems that were encountered:

1. Design of equipment with close temperature control for converting furfural to furan. The design finally settled on employs a large number of tubes containing a catalyst, with a coolant circulated around them. Special sequence timers were devised for operation of the valves controlling production and regeneration cycles.



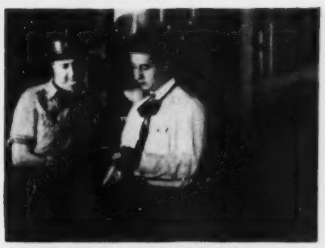
Scale model *of a part of the plant where adiponitrile is made from furfural.*

2. Design of high-pressure agitated autoclaves for the hydrogenation of furan to tetrahydrofuran.

3. Selection of corrosion-resistant equipment for the hydrochlorination of tetrahydrofuran to dichlorobutane at high temperatures.

4. Design of a unique five-step distillation train to obtain high-grade adiponitrile without trace impurities.

Although most of these problems involve a great deal of chemical engineering, also needed on the designing team were mechanical, electrical, civil, metallurgical and industrial engineers. Thus design work at Du Pont is open to men with many types of training, and there is abundant opportunity for all.



E. W. Griffin, *B.S. in M.E., Duke; M.S. in Ind. Mgt., Georgia Tech '52 (right), instructs operator in handling of vapor-tight horizontal vacuum filter used in separating adiponitrile from sodium chloride.*

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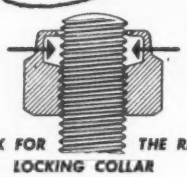

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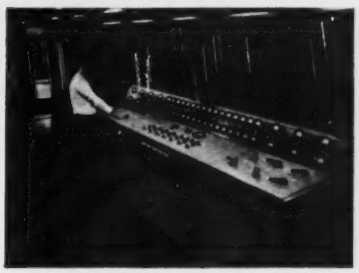
25 strands of steel wire start on their way to be electrolytically coated with copper, lead and brass.

Part of the 600 foot long electroforming machines where wires go through successive baths of plating solutions.



Console of controls for entire process is readily operated when necessary, even though seldom used in the almost fully automatic operation.

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Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

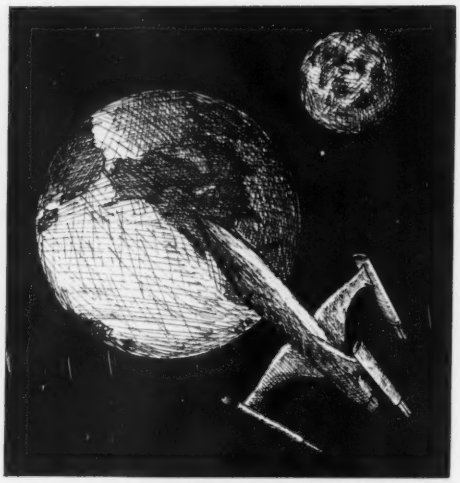
requiem

By Knute J. Nomland, '55

The hill is jet against a blood-red sky where malignant clouds, dark and stormy, brood over the silent earth below. A lone figure trudges up the slope and stands, wearily, gazing with resignation at the tempestuous surf below, at the sea which, mirroring the sunset sky, flames with a thousand shades of red. The beach curves away to the north where, a few miles away, lies another sea, a dead wasteland of frozen magma. This wasteland was, not long ago, a teeming metropolis, a city of life, with skyscraper scarps piercing the heavens, proud monuments to the engineering genius of their builders. There burn the cold fires of radioactive disintegration, a furious blue glow, bright even in the blazing sunset.

The solitary one on the hill sees all this, and yet he cannot comprehend, for he is tired, tired with the exhaustion born of complete futility. He thinks, despairingly: "Gone . . . everything gone. Just like children, they were, playing with the fire that burns and destroys . . . but they're gone, too. O Lord! . . . What am I to do?" And he moves off, searching hopefully for the living in this land of the dead.

Far above, floating in the chill, black immensity of the void, is a tiny speck of bright metal. Within, in a dimly lit cubicle, two beings stand, watching a screen

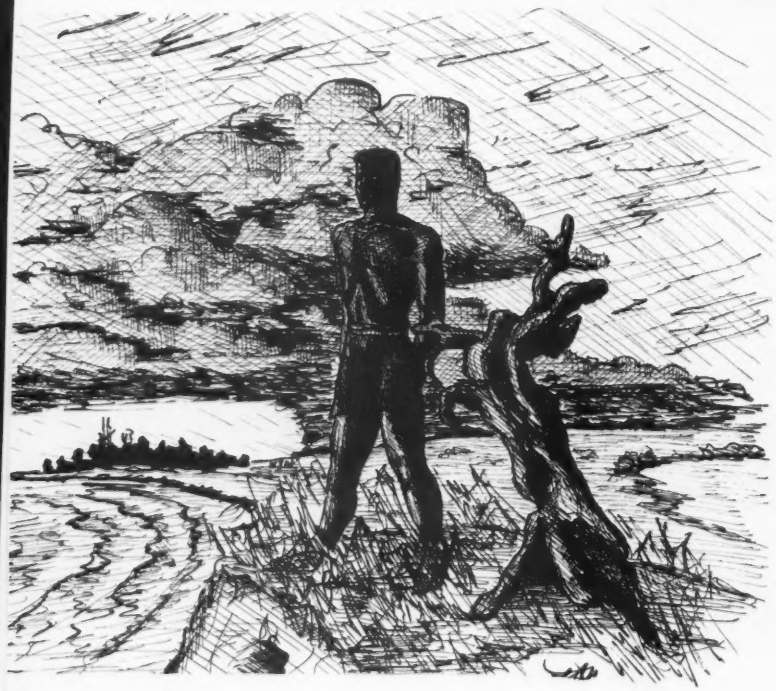


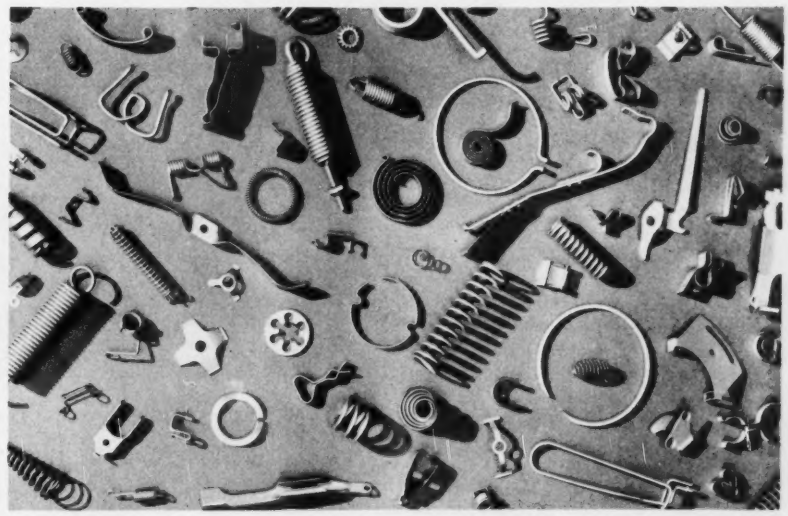
on which is imaged a portion of the devastated planet beneath. One speaks, in a tongue as alien to this star system as the far-off galaxy that sent him forth.

"I fear, my commander, that we have come too late to do much for these people. A pity that the Intergalactic Survey could not have reported sooner their findings on this planet."

And the other sadly replies: "A tragedy, indeed. I cannot help but wonder at the greatness that might have been theirs. You read the Survey report. They were a young but brilliant people — too brilliant, in fact. In a few millennia they reached a technological level that our race was a million years in achieving. That was their greatest failing. You see, they did not have the understanding of themselves that comes only with time. They never really learned to live together, to act as a racial whole. The rapid expansion of their technology gave them the means to facilitate their own doom. You might say they were like infants, little children playing with fire."

Gone is the race of man, his brief existence in this universe at an end. Just as his works must crumble into the primal dust, so will he be lost in the eons of cosmic time, unremembered and unmourned.





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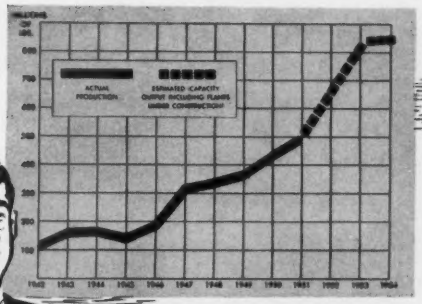

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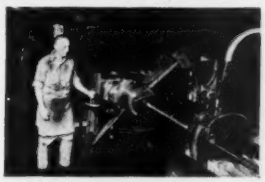

Tube drawing, one of many mill operations at Reynolds

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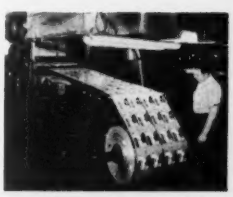

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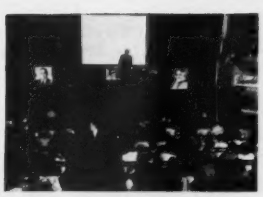

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impure science

By Philip Wylie

Famous Author and Thinker

(Reprinted from *Bulletin of the Atomic Scientists*)

It is said that "pure science," the quest of "knowledge for its own sake," embodies the loftiest of human motives. Indeed, this idea is so well imbedded in the minds of investigators that I have known several who imagined it to be not just the dominant motive of their lives but the only important motive.

In them, "pure science" corresponded to what other men call "God." It was their Grail and their *raison d'être*, their be-all and end-all, so they thought. And like all other devotees they allowed nothing of which they became aware to interfere with their selfless self-dedication. Pragmatism governed their work; logic, they said, ordered their minds. They ruled out emotion — unless the very asceticism which rejects feeling and sentiment is, itself, an occult emotion.

To be sure, none of these gentlemen was a perfect monk of the laboratory. They came outdoors. They associated with people and even people who were not scientists. They usually did not belong to churches but some belonged to political parties. Others, finding no party to match their theories of government, joined nothing but willingly expounded their own social conclusions. These gentlemen were often married and often had children. In domestic relations, they were not markedly more successful than other men. And in learned areas outside their own they often exhibited credulity, ignorance, prejudice, *à priori* conclusions, and other phenomena characteristic of the rest of us — the biased vulgarians.

Their scientific "purity" as people often was heart- and brain-deep in their elected province of research. Elsewhere, it was sometimes skin-deep, sleazy, or non-existent. But as I have pointed out before, in their work these same gentlemen would not employ any tool — any gauge, say — which they had not tested in every way and found reliable. They would not use a gauge they did not quite know how to operate or a gauge that often stuck or a gauge with calibrations upon which they were not agreed. Nevertheless, they constantly employed as their master tool, themselves — organisms very few of them bothered to check against an increasing body of scientific knowledge concerning humanity.

Common man invents the myths, as a rule. But one common myth which the pure scientists readily took for their own, lived by, promulgated, and gave official sanction to, was the myth — the inexcusable myth — that science has found out so much it is impossible for any individual to keep up with the Known.

That is perhaps the Great Myth of the twentieth century. It appears true on its face. No man can possibly master the detail of every branch of inquiry and give it back perfectly on demand, like an encyclopedia. But any intelligent man who is not misled by the myth can quite readily assimilate the basic concepts of all the sciences, the principal lines of investigation they are following, and the major new developments as they occur. He can "ground" himself by reading one or two hundred books (not necessarily the "Great Books") and he can keep effectively abreast by following a dozen journals and magazines. Many persons do just that — including even a few scientists.

Thus, what a man can learn concerning his physical environment and concerning those responses to it which he calls his "psychology" may embrace the main, current notions about all that is "known," from the composition of atoms to the nature of the cosmos and from the laws of genetics to those of the unconscious mind, including even his own unconsciousness. He can *understand* these many hypotheses, that is to say — and something of evolution, anthropology, archeology, and a score more sciences, to boot. In every important field, numerous able men have set *the* major findings into language a bright high school graduate can easily follow.

Yet The Myth is universal. Its many corollaries are taken for granted by the learned doctors as much as by the veriest oafs. A principal corollary is this: not since the era of Shakespeare (Spencer, perhaps, Newton or Bacon) has it been possible for the individual brain to grasp contemporary knowledge. If a man follows what has been found out in, say, Medicine, he will have no room in the furrows of his brain even to glance at what the Nuclear Physicists have learned. If he is gifted enough to contain the basic elements of Medicine and Nucleonics, there will surely be no drop of grey matter left to soak up any data on Semantics, or, perhaps, the new Psycho-philosophy of Symbols.

That corollary is rubbish. For, obviously, every intelligent modern man can and does soak up far more than was contained in Shakespeare's "universal awareness" and likely, in addition, he specializes in something that conducts him, in one area, at least, far beyond the Bard — three centuries and more beyond. Why, then, does a preposterous fable underlie (and delimit) all — or nearly all — our private pretensions to knowledge?

It is convenient. It perfectly serves the philosophy that has reigned over pure science for more than a century, the philosophy of specialization. The myth makes it apparently possible for the investigator to proceed farther along a single line than he would if he had been obliged to attain something of a general education before specializing. I say "apparently" owing to the fact that much evidence could be put forward to show how knowledge in all areas aids inquiry in any one and to the further fact that special lines of inquiry converge and merge, these days, so that it is difficult to sort out one "science" from another. Genetics, to illustrate, is part of Biology, but when Shrödinger writes about it, Genetics suddenly becomes a branch of Nuclear Physics.

It will be argued, of course, that the very object of "pure" science is to rule out what I have called "man" and that the aim of "knowledge for its own sake" is the attainment of information without regard to human beliefs, passions, and will. True — and noble, besides. Yet if that is all of truth, it follows that certain other "ideals" we hold dear are most unrealistic. Democracy is one. Scientists never tire of advertising the "democracy" of their occupation. Yet democracy rests upon the political theory that a majority of any

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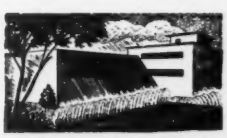

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group, when adequately informed, will make appropriate decisions.

It will be seen at once that, so long as the Great Myth is believed, real "democracy" remains an illusion. For, to the extent that scientific findings influence society, the voters, believed incapable of universal insight, will not be adequately informed. They will not be one per cent adequately informed. They will even assume they cannot be and many important scientists will assure them that is the case. Moreover, scientists themselves will be little better off. For, wherever a social problem falls outside their particular domain, they will (as unchecked gauges and because of The Myth) share ignorance with the laymen.

That, of course, is the actual state of affairs today. Mr. Truman, who did not go to college, is trying earnestly to calculate risks of war that involve shocking guesses even for nuclear experts. He is assisted by Mr. Dean, who is not a physicist, by Mr. Acheson, who is probably unable to think of a future war as a bacteriologist might, and by General Marshall, whose background in the studies of fungi is probably nil. It was that sort of "democratic" difficulty which led some of the scientists I have known to subscribe to naziism and others to communism and which fills a great many more with a sense of pessimism-cum-dilemma. A people who, for generations, have been taught that they cannot know, but who nevertheless must act, do so then in avowed ignorance which, usually, they call Faith.

The assumption that the public could be turned overnight, or in years, or in a generation, even, into technological sciolists, is, on the other hand, foolish. A vast body of the public, a large majority, will long remain uneducable in science owing to its cerebral incompetence, its more superficial motivations, or its religious doctrines.

Yet there existed, until recently, here and abroad, among many national majorities, not only an assent to scientific research (even where support was absent) but also an emotional climate or a "philosophy" which fostered inquiry. The general term given to that climate, that philosophy, was "freedom." Insofar as science was concerned, such freedom has long been taken for granted. Under it, science advanced, advancing the people with it!

What modern men of science took too much for granted was a brand of that same "freedom" accorded constitutionally to Americans: freedom to investigate as they pleased so long as they did not harm other people; freedom of their scientific press whereby their findings and theories could be communicated; freedom of assembly, wherein they could report and discuss their work. Western man for a long time maintained that franchise for scientists. The masses did not become "science-minded" and did not believe it possible; but they firmly believed (or seemed to believe) that scientists should be allowed to go ahead — freely and openly. That much "democracy" we *had* achieved!

The Nazi dictatorship, with its quasi-heathen "religiousness," blurred such liberty somewhat, but only locally. Geneticists, at least, are nowadays aware that the Communist dictatorship has not only muffled freedom but altered fact to suit its politics. And American physicists, these days, are anxiously metering the air to find out what Soviet experts are up to — more evidence of the world-wide loss of a free climate.

It does not lie within the province of this brief essay to inquire into the meaning of such events from a technical, psychological standpoint. Psychologists and psychiatrists pointed out the signs, portents, and warnings long ago. They saw, in fascism and communism, a regression of Western man from scientific truth and from the climate of freedom toward medieval patterns; they explained it. Any physicist interested in the literature can find it without difficulty though he may deplore it, since most psychologists are not very pure scientists, being doctors, not biologists, and doctors, besides, who are inquiring into a new, uncertain area of truth.

What the "pure" scientists needed to appreciate, and did not, was that the climate of liberty which they took for granted was not necessarily self-sustaining. Few, however, had a concept of themselves as tools in need of as much checking and adjustment as the rest of their apparatus. Fewer still, as a result, appreciated that a function of the pure scientist involved the maintenance and extension of the general function. Humanity could not be rendered logical in all ways and rapidly; but large groups had already become attached to the idea of freedom. So long as this was kept before them as an essential condition of advancement, the people might feel they had "the right" to debate scientific discovery on grounds of dogma or tradition or whatever, but they would also feel obliged to permit a similar liberty to the investigators.

The "purer" the work of an individual, the larger was his obligation to freedom for he used it more. His brain was his final tool. Its only effective medium was liberty.

Without liberty, the direction of his work could be impeded, his conclusions could be repudiated, and his very hypotheses could be stifled. At the core of learning, the center, the heart, the apex, there might be no "free press" without liberty and no right of "free assembly." To keep "pursuing knowledge for its own sake" where such rights no longer existed would be to perform an act of solipsism, an act of ego and vanity amounting to pathological behavior. For, in the ultimate sense, to pursue "knowledge for its own sake" is absurd; if man's sake is left out, the pursuit must logically be abandoned: the knowledge already exists in the universe; why should any man uncover it save for some human reason?

From that "human reason" for science devolves the human responsibility of scientists for freedom. Freedom, fundamentally, is the room for learning. It is the space, the dimension, in which the mind may dis-

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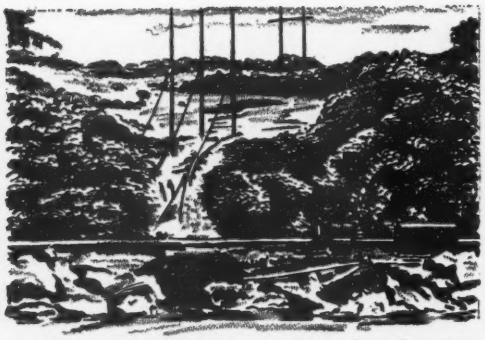

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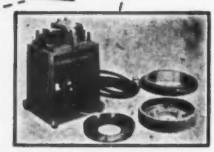
Gage Head Cartridge mounted on a fixture to measure a fixed gage—used with Amplifier.



Special fixture utilizes Gage Head Cartridge and Amplifier to measure internal angle accuracy to ±1½ seconds.

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impure science

cover and grow. It has but a single absolute: freedom of knowledge. This, the scientists have regarded as their very own. They have done it much service by trying to tell all people what they know and by urging any who will to join their ranks. But when, in America, the crisis came, very few scientists indeed saw fit *as men* to defend that needful absolute with valor and resolve. There were few martyrs after Hiroshima. Instead, there were people who refused to work for the government, or for Leslie Groves, or upon weapons. There were people who viewed with alarm the closing of a federal curtain over a portion of physical theory. There were polite, worried lectures. But the scientists of America did not stand as one to cry out, "This shall not come to pass!"

The medium, the environment, the public philosophy which their brave predecessors had so agonizingly brought into being was overnight contracted and compromised. Hardly one scientist in fifty looked up from his Bunsen burner to note what had happened. For the first time in America freedom of knowledge was, in part, officially dead. There was a seal over "X" amount of truth. From thenceforward, all but the sanctioned few would be unable to learn even the general nature of what they were not allowed to know.

A surge toward enlightenment that began with Aristotle, with Jesus, even with the old Asian philosophers, once more was stopped and no man could say how far the curtain would fall before the principle was restored. But the scientists — even the pure scientists — did not deem themselves responsible. They neglected their tradition and their heritage. The culture medium, the liberty, in which they had grown was polluted without much protest.

They had, it proved, merely exploited liberty for they would not express it or exemplify it. In that fashion, they were not good gauges — not pure men, wherefore not pure scientists. And that is why, today, so many of them talk vaguely of their collective "sin."

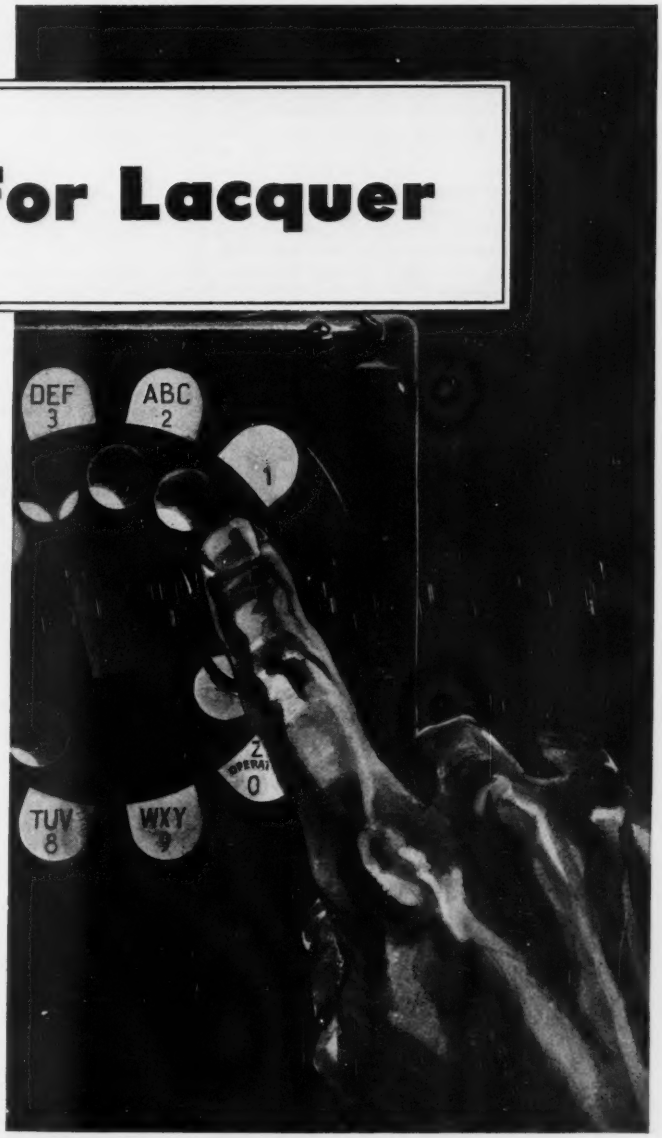
That all other liberties had their roots in their own fundamental freedom of knowledge was *not* apparent to them. They were swayed by lesser traditions, or owned by businesses or universities or governments — or they had replaced their one valid idea with "social consciences" — or they were "believers" in this or that. When liberty was thus slain at the source her mourners were mostly laymen, like myself.

It was a curious period, the weeks and the months following Hiroshima and Nagasaki. The "atomic scientists," pitched suddenly into the brightest of all limelights, asked and even pleaded for an "open" world.

But those whom I knew were far more alarmed by an immediate prospect. During the war they had worked under the army and they were determined, with the coming of peace, to throw off the military yoke. They merely insisted that science, if it had to be regulated or in part kept secret, must be under civilian, not military authority. To that end they bent nearly all their effort, urging men like myself, who understood something of physics and who "could write" and who had "large audiences," to campaign for the McMahon Bill and against the May-Johnson Bill. When the former passed, they sighed with near-complete relief: civilians, not soldiers, would possess the atom.

I argued then as I do now: scientists cannot accept *any* such authority and still call themselves by their old name. I argued then that civilian authority in a secret world would not assure peaceful development of

Calls For Lacquer



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atomic energy (as so many scientists anticipated) but would, as much as military authority, find it necessary to arm against a secret, arming adversary. I argued that, with the principle of freedom submerged, the area of existing liberties would steadily shrink. That a growing, secret knowledge of the atom would slowly spread a nameless terror among a people unfamiliar with secret government, was the inevitable concomitant.

I protested that trust in secrecy was childish, not only on the acknowledged basis that American "secrets" could be re-discovered, but on the basis that espionage at high levels was a certainty. I protested that the curtain of silence across a portion of physics unjustly cut off all philosophical men from their rightful sources of material for speculation. I predicted that, in a closed world, an arms race would ensue which would destroy genuine liberty, and undermine tranquillity by intensifying terror down the years — with all the horrible social results of terror; and I asserted that, when fear and tension and dictatoring reached some sure but unmeasurable degree, Armageddon would come automatically.

The conclusions to which those arguments and expectations led, were these: we Americans, standing loyally for our one absolute of freedom of knowledge, were obliged to insist (if necessary) on a free and open world even at the risk of immediate war with Russia. It was not a great risk in 1945 for Russia was decimated and our arms were omnipotent. It was their duty, the essence of their purity, that the atomic scientists should make the issue clear — refusing as one to accept the narrow liberty even of civil dictation where the far broader base of everybody's freedom was at stake. Nothing short of the threat of force would ever compel Russia to assent to world freedom, for the Kremlin could not persist as it was constituted if "inspectors" from the wide, free world were allowed to see what the Kremlin had done and was doing to two hundred million human beings.

Those conclusions meant that I believed we should fight at once rather than abandon one jot of American freedom of knowledge. Fight in 1945. In 1946. Or now. I then believed that scientists, led by the nuclear physicists, should dramatize the issue — if necessary, by striking — not against the government per se but against *any* policy of secrecy. It seemed their duty.

The issue was a clear one between the continuum of freedom, of pure science and pure scientists, and a retreat into the self-enslavements of a new medievalism and a new kind of political dictatorship. So simple was my mind that I believed the risk of war a lesser folly than the loss of freedom. I still do. An American public, faced with the flat refusal of scientists to accept secrecy, would have been obliged to take charge of Russia, by force if need be. The world, including the people of USA, would have learned a mighty lesson in freedom. And Doomsday would not be around the corner now.

But the scientists, like the politicians, appeared to think we could safely abrogate our most basic right until we had settled the issue in the United Nations with a Baruch Plan, or something. Both evaded principle; both seized what seemed to them an opportunity for less costly politicking. And nothing whatever was accomplished. In the end, Russia was allowed to commit a gigantic act of aggression against us — an act that cost us our one binding ideal.

Today, the United States of America is a quasi-dictatorship operated chiefly by civilians for military ends. Neither the voter nor his representatives in Congress have any adequate insight into the basis of policy. Neither has enough information to appraise in any useful fashion the perils of our quondam Republic. We do not know what weapons we have or what ones our potential enemy may have. Billions are spent without our comprehension.

We are being prepared — we are not told how — for a war the nature of which we guess and dread but do not really know, a war that grows more terrible every time a scientist has a new hunch here or in Russia — by men who hold this formidable power over us but who have no background for understanding or for extrapolating on the sciences they intend to apply and to oppose. It is no wonder that millions of Americans look toward the future with apathy, or despair, or simply refuse to look. Much that "citizenship" and "government" used to mean has already disappeared; in its place has come a progressive horror as real as lightning but nearly as secret as the other side of the moon. Psychologically, we laymen of the world are reduced to the situation of barbarians again; it will not be astonishing if, come Gabriel's Atomic Trump, we behave barbarically.

In that situation, I think, lies a fact that at least partly explains how the chain of disaster commenced. To the atomic physicists and their associates in engineering, after Hiroshima, "secrecy" did not seem a great menace. They had worked under it for years and had come to feel it was chiefly "military" secrecy which was odious. They expected, furthermore, that under civil authority, they would be "cleared" to know what few secrets of atomic ordnance would be preserved. Their own access to knowledge thus would not be diminished — they thought.

So they felt no sense of personal disaster, of private loss, in the prospect of putting underground a little of their applied knowledge or even some "pure" segments of it. Like other men in short-sightedness, they did not adequately dread what they thought would not harm them in person.

They were a little awed at themselves, too. They had contrived something so colossal that they felt they needed help — the help of everybody — in deciding what to do about it in the future. They seemed to feel their own principles, however lofty, should be subjected to public review and possible revision. They asked for guidance, in short, where they should have been best equipped to guide.

That, I believe, is the case against the purity of our scientists.

We still go through the motions of "free men." We continue to talk about the "free peoples" of the world. Meanwhile, in secrecy and all alarming sorts of semi-secrecy, those who actually make our decisions are busy building atomic engines of massive destructive capacity — and busy urging the inhabitants of our cities to prepare themselves to be struck (harder and in more places with passing time) by the same sorts of missiles. It is entirely possible, as certain learned Japanese have suggested, that the nervous system of *genus homo*, whatever his preparations and "civil defenses," simply will not support atomic bombardment.

It is evident, in such case, that any "next war" will be supremely a "war of nerves" in which not necessarily the most sensitive but likely the least sensitive peoples will endure longest and emerge victors by default. And it is obvious, to any physicist worth his salt, that man is not at the end of his weaponeering capabilities but, rather, at a fresh beginning. The "arsenals" of democracy (or of the Soviet) by 1960 will probably contain

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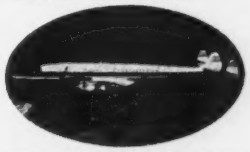

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impure science

engines potent enough to wipe out life in areas as big as, say, New Jersey — with better ones in prospect. That is the sort of predicament we face because we did not stand, when we could have stood and should have stood for liberty: for a simple freedom of knowledge, lawed on the world by ourselves if need be, in order to preserve it at home.

It is quite a predicament.

As a citizen, a layman, and what is called a "lover" of freedom, I watch with unusual interest to see if my friends, the impure scientists, will even get me out alive, let alone get back the liberty I and they have lost.

History some day will notice, I suspect, how near the Americans came to a general realization that all liberties are conditioned by knowledge, and hence freedom of knowledge is the perpetual key to the rest — the absolute, the Great Ideal, to be extended among all men and defended on every perimeter. History will note, also, how we failed there in our current crisis and how the weakness of our adversary — a lack of that very concept — became at least somewhat our own weakness. Whether we shall gain a new vision of the principle in the ferocious years ahead, no man can say. Layman and scientist alike can but hope. But if we do, millenium will be at hand.

The problem of "loyalty" becomes rather trivial in such a frame of reference. Certainly, if my criteria are regarded as in any degree sound, not Russia nor any land but this, offers a good hope of liberty restored. So, I feel, the scientist who understands whence science came and of what ideas he is composed need hardly cavil at the signing of infantile oaths. He has always been asked to sign a similar one upon going abroad, in order to get a passport. Should he object at home?

Should he object even as a special person, one singled out — when he has bent his days to be just that special? Should he demur because the pressure to sign is exerted by men who patently do not comprehend freedom? If so, how can he arrange his logic, since he, the scientist, more than any other kind of man, is responsible for the loss of liberty that has given power to bigots? Let him sign!

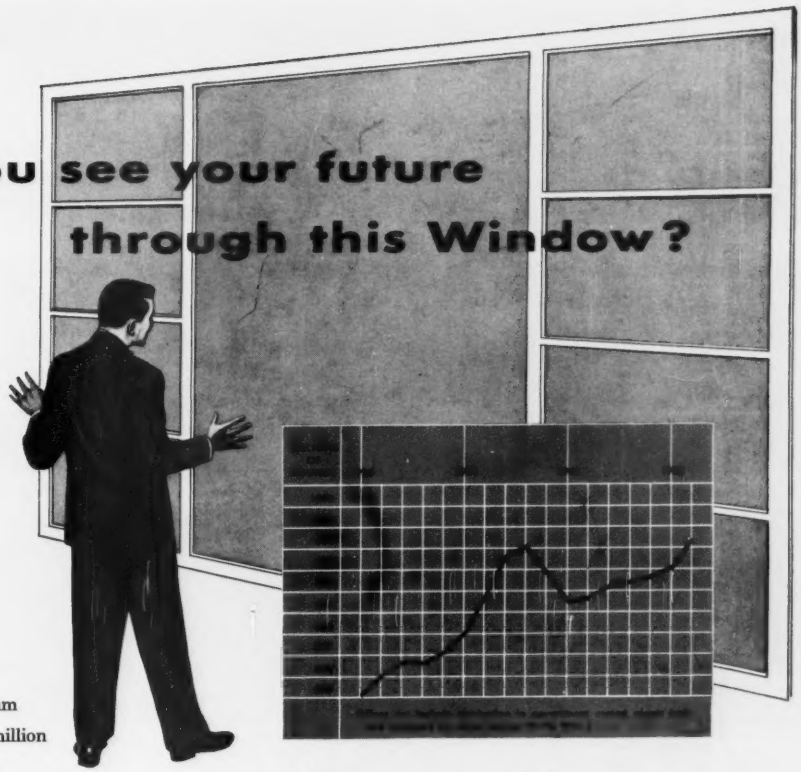
Let him sign for a shrewder and more humorous reason than he has caught sight of in all this petty squabble over "rights." Suppose the angered scholars and savants in California had, instead of resisting to the point of excommunication, signed up to the last professor? They could have said, "Now, gentlemen of the Regents, we signed 100 per cent so where are the Commies?" For all the Communists would have rushed to fix their names, and a completed list would then have thrown the problem of "guilt" back into the laps of the stupid pesterers of the people who saw liberty so narrowly, so personally, so theologically — in its sense of befuddled argument.

The only possible deep loyalty left for a man of science, if my observations are even somewhat correct, is loyalty to that arming horde which may restore freedom in a pure form. Loyalty is certainly not due a nation that eschewed the concept of freedom and even the very method of science at its ideological beginnings.

Is it not, then, paltering to refuse to swear what one ought easily to be convinced of and to believe in? I would grant a man of science or any man the right to refuse in a truly free country — even the duty. But the current haggle over loyalty merely shows that some of our investigators and students have not yet realized the sort of world in which they now live. It is — all of it — an army and our "side" will remain an army, let us hope, until a victory is won for ideals lately and all too easily relinquished. In an army, one signs what one is told to sign. And the superior officers of what remains of civilization are not men who understand the management of intellect but men who know how to manipulate emotions. With dread dominant, that is quite easy and inevitable, also.

It is too late and too soon to repent of impurity and sin. It is a time to fight. Our abandonment of freedom has left us with no better means than cunning and its final resort: force. But when and if another chance is offered, let the scientists remember the true name of their error: ignorance. For the knowledge they severally have found has made naivete synonymous with death. Complete, not partial or specialized sophistication is the only way that remains to man for the achievement of his dreams. Fortunately, it is the good way, the scientific way. There is no place for children among the wise; but the wise will study childmindedness with intent compassion, to lead a world of child-adults away from self-harm and, let us hope, to avoid further contamination in the future.

Can you see your future through this Window?



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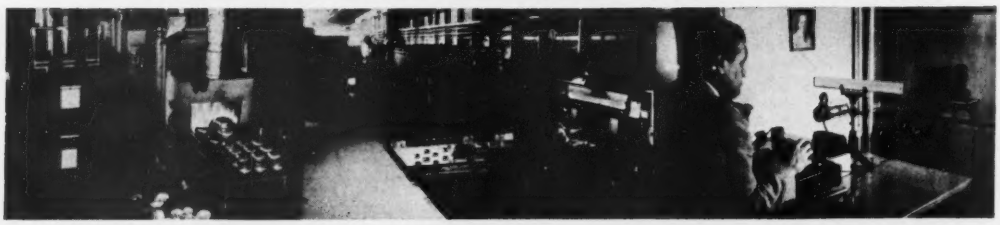

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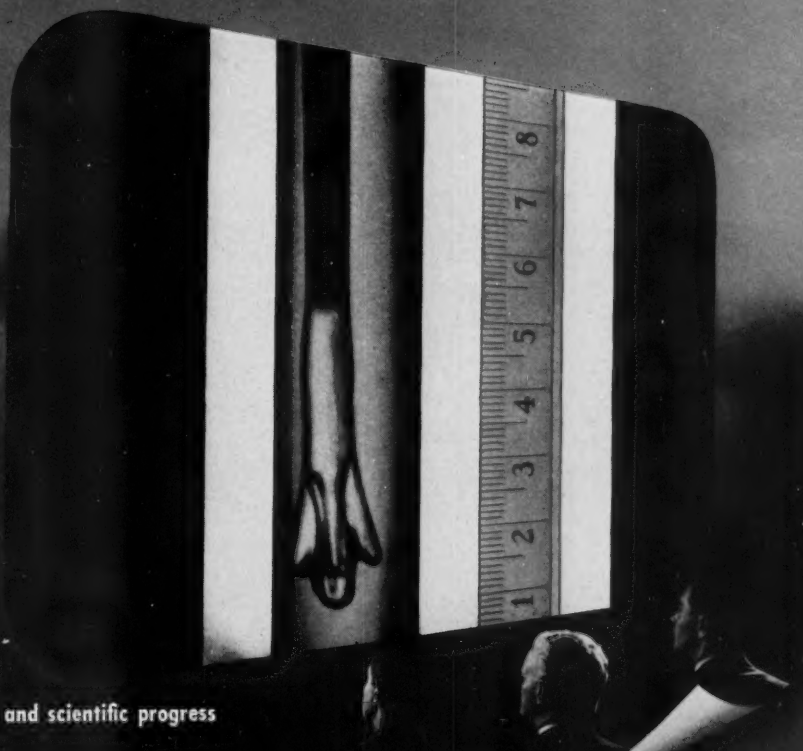

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